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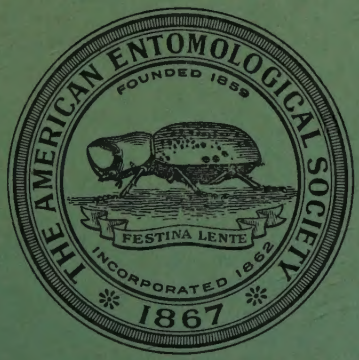

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THE SPECIES OF THE GENUS AEOLACRIS SCUDDER

(ORTHOPTERA; ACRIDIDAE; ROMALEINAE)

BY JAMES A. G. REHN

Curator of Insects, Academy of Natural Sciences of Philadelphia

The author has long been aware of the very unsatisfactory state in which the specific systematics of *Aeolacris* have been since 1916, when Carl,[1] on the basis of a single specimen, and with no type material before him, sweepingly synonymized several species by American authors, without having seen authentic material of either of them.

The crux of the whole situation is the identity of Scudder's genotypic species *octomaculata*,[2] and a recent visit to the Museum of Comparative Zoology, at Cambridge, Massachusetts, where the classic Scudder series is now, permitted me to make physical comparisons of available material of the genus, which warrant the presentation of this paper.

Material of *Aeolacris* is rare in collections, and in over a half century of study work I have seen but five specimens, two of these types and one a paratype, and of the five, three are in the Academy collection. It so happens that one of these components of our series is the first female I know, or can find mentioned, of the longest known member of the genius, i.e. *A. caternaulti*. This specimen is here described and figured, having as it does a very different ensemble from the male sex of the species, judging from Feisthamel's very good original illustration of the latter. Giglio-Tos' description and measurements of the female of Scudder's *octomaculata* show that in some respects it differs from the female of *caternaulti*, and apparently is less divergent from the male sex than is the female of *caternaulti*.

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[1] Revue Suisse de Zoologie, XXIV, pp. 502-504 (1916).

[2] Proc. Boston Soc. Nat. Hist., XII, p. 337 (1869).

Discussion.—J. Carl [1] reviewed the confusion which had existed in the minds of certain previous workers as to the proper generic positions of Feisthamel's *Xiphicera caternaulti* of 1837, and Serville's *Xiphicera octolunata* of 1839, and reaffirmed, from the evidence of a male from Cayenne, both Scudder's [3] and Pictet and Saussure's assignments [4] of the former name to *Aeolacris*. Carl supported Giglio-Tos' conclusion [5] that *octolunata* was a member of the genus *Elaeochlora*, while more recent work has brought out the fact that *octolunata* was based on the male sex of *tricristata*, also of Serville, and which has two pages priority.[6] There has been a difference of opinion in the minds of workers as to whether *Agriacris* Walker, 1870, is a distinct genus, or the same as, and an older name for, *Elaeochlora* Stål, 1873.[7] However, this latter point is aside from the question which has been determined, i.e. that *octolunata* is not a member of the genus *Aeolacris*.

To this point Carl was on warranted grounds, but the temptation to theorize without supporting evidence then induced him to create synonymy which is far from warranted, and at the same time to make a sweeping assumption as to the distribution of *Aeolacris caternaulti*, without seeing any of the historic material of the species which he had synonymized, and which were involved.

Feisthamel's *Xiphocera caternaulti* [8] is clearly a member of Scudder's genus *Aeolacris*, and I am describing and figuring beyond what I regard as the previously unknown, or at least undescribed, female of that species, this being, also, the first female of the genus to be figured. Carl, unwarrantedly, doubted that I had seen the original description of *caternaulti* when in 1909 I described *A. bella*.[9] He should have noted from my writings that it is a rule with me to show, by quotation marks, any reference cited which I have not been able to examine personally. It fortunately

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[3] Proc. Boston Soc. Nat. Hist., XVII, p. 269 footnote 1 (1875).

[4] Bull. Soc. Entom. Suisse, VII, p. 340 (1887).

[5] Bollett. Mus. Zool. Anat. Comp. Univ. Torino, XII, no. 301, p. 3 (1897).

[6] Hebard, Trans. Amer. Entom. Soc., XLIX, p. 219 (1923).

[7] Hebard, Trans. Amer. Entom. Soc. XLIX, p. 220 (1923); Rehn, Notulae Naturae, no. 66, pp. 1-2 (1940).

[8] Magasin de Zoologie, 7, pl. 184 (1837). [♂; Cayenne.]

[9] Proc. U. S. Nat. Mus., XXXVI, p. 114, figs. 3-5. [♂; Rio Purus, Brazil.]

so happens that the library at the Academy is far richer in its coverage of older European works than all but a very few of those in continental Europe, and two sets of the serial containing Feisthamel's description are within our institution.

Scudder's *Xiphicera octomaculata*,[10] later in 1875 made the type species of his genus *Aeolacris*,[11] is a radically different species from Feisthamel's *caternaulti*, on the basis of the latter author's original description and figures, and the evidence of Scudder's unique type, which has been compared with a male of the same species reported elsewhere in this paper, and with the paratypic male of my *A. bella*. I. Bolívar's *Aeolacris giglio-tossi*,[12] which Carl did not mention, and may not have known, is clearly a synonym of Scudder's *octomaculata*, the Baños specimen here reported agreeing fully on one hand with Bolívar's description, and on the other with the type of *octomaculata*, with which it has been physically compared.

As the following key to the species of *Aeolacris*, on the basis of the male sex, shows, there are two distinct lines in the genus, one including solely *octomaculata* (Scudder), the other consisting of *caternaulti* (Feisthamel) and *bella* Rehn. The former may be limited to Upper (or even Subandean) Amazonia, the latter line extending from Central Amazonia eastward. This is rather far afield from Carl's sweeping assumption of a single species of the genus extending over "une très grande partie de l'Amérique du Sud tropicale."

The differences between the two sections of the genus may be summarized as follows:

1. Tegmina as a whole broader, regularly narrowing in distal half, their apices definitely and sharply oblique-truncate, with distal portion of costal margin not strongly rounded to the apex. Apex of wings subacute angulate; transverse nervures of hyaline area less numerous, more widely spaced. Angle of caudal margin of pronotal disk subrectangulate. Lamellate spines on caudal tibiae proportionately longer. 2

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10 Proc. Boston Soc. Nat. Hist., XII, p. 337 (1869). [♂; "Napo or Marañon" [Rivers, eastern Peru or Ecuador].]

11 Proc. Boston Soc. Nat. Hist., XVII, p. 269, footnote 1 (1875).

12 Revista Chil. Hist. Nat., XIII, p. 349 (1909). [Sex not stated, but clearly ♂; Ecuador.]

Tegmina as a whole narrower, in distal sixth only showing further apical narrowing, their apices roundly oblique-truncate, with distal portion of costal margin briefly but strongly arcuate to the apical margin. Apex of wings more rounded, costal margin more arcuate distad, in this corresponding to the outline of the tegminal apex; transverse nervures of hyaline area more numerous, less widely spaced. Angle of caudal margin of pronotal disk appreciably acute produced. Lamellate spines on caudal tibiae proportionately shorter. (Eastern Ecuador and Peru.) *octomaculata* (Scudder)

2. General form somewhat more robust, relatively stouter. Pronotum, as seen from dorsum, somewhat broader. Tegmina with greatest breadth at proximal third; apices less markedly oblique. Wings narrower, with apex of axillary field less strongly produced. Subgenital plate shorter, less strongly aciculate produced. (French Guiana.) *caternaulti* (Feisthamel)

General form more elongate, more slender. Pronotum, as seen from dorsum, narrower. Tegmina with greatest breadth mesad; apices markedly oblique. Wings broader, with apex of axillary field more strongly arcuate produced. Subgenital plate longer, more strongly aciculate produced. (Rio Purus, Amazonian Brazil.) .....*bella* Rehn

Aeolacris octomaculata (Scudder) Plate I, fig. 1; pl. II, fig. 4.

1869. *Xiphicera octomaculata* Scudder, Proc. Boston Soc. Nat. Hist., XII, p. 337. [♂; "Napo or Marañon" [Rivers], eastern Ecuador or Peru.]
1909. *Aeolacris giglio-tossi* I. Bolívar, Revista Chil. Hist. Nat., XIII, p. 349. [Sex not stated, but clearly ♂; Ecuador.]

EASTERN ECUADOR OR PERU: "Napo or Marañon" [Rivers]; 1 ♂ (type of *X. octomaculata* (Scudder); [Mus. of Comp. Zool.].

PERU: Baños,[13] altitude, 1800 meters; (F. Campos R.); 1 ♂ [A.N.S.P.].

The type of *octomaculata*[14] has been dried from alcohol, is badly shrivelled and discolored, but pattern elements are still clear. It lacks the left caudal limb. When compared with the Baños male here recorded, the type of *octomaculata* shows no noteworthy difference except that the two pale yellowish spots on the proximal half of the left tegmen of the type are separate, while they are joined in the Baños male. The right tegmen of the type is patterned as in that from Baños. In both, the dark brown outlining of these pale markings is well indicated. There can be no question of the specific identity of the two specimens.

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[13] Baños is now regarded as Peruvian and in the state of Loreto, although that portion of the eastern slope of the Andes was long considered part of Ecuador.

[14] This is labelled "Scudder's type 1875" as are the other South American types of that author which were in his collection. It is now M.C.Z. type no. 15797.

The measurements (in millimeters) of the two specimens examined are as follows:

	Length of body	Length of exposed portion of head	Median length of pronotum	Greatest breadth of pronotal dorsum	Length of tegmen	Greatest breadth of tegmen	Length of wing	Length of caudal femur
"Napo or Marañon", *type*	41.0	6.5	10.0	6.0	38.5	7.5	36.0	25.0
Baños, Peru	46.0	7.0	10.6	5.8	39.0	7.3	37.5	26.0

The wing disk in the Baños male is salmon pink except for the clear fenestrate section. The base color of the body is a dull olive-green, with the pale dorsal line very dull greenish yellow, the tegminal pale areas a lighter, nearer sulphur, yellow, while the oblique lateral paler areas are dull buffy washed with greenish.

When these two specimens are compared with the paratype of *bella*, it is seen at once they represent a very different form, the distinguishing features being used in the preceding key to the species of the genus.

Giglio-Tos recorded both sexes of this species from the Valley of Santiago,[15] which was then considered as in Ecuador, but now placed in Peru (state of Amazonas). Unfortunately his comments on the female sex tell us little regarding it.

Aeolacris caternaulti (Fiesthamel) Plate I, fig. 2; pl. II, fig. 5.

1837. *Xiphicera caternaulti* Fiesthamel, Magasin de Zoologie, 7, pl. 184. [♂; Cayenne [= French Guiana].]

French Guiana: Maroni; 1 ♀; [A.N.S.P.].

The preceding key supplies what I regard as the salient points of difference between this species—known so far only from a limited portion of the Guianas—and my *bella* of Central Amazonia. While *caternaulti* is a somewhat more robust insect than *bella*, judging from Fiesthamel's two figures of the male, it apparently is slightly smaller. The subgenital plate is much less aciculate produced than

[15] Bollett. Mus. Zool. Anat. Comp. Torino, XIII, no. 311, p. 51 (1898).

in *bella*, while the tegmina are narrower with the costal margin less strongly arcuate, while the wings are narrower and sharper, and with the axillary field definitely less arcuato-lobate at the peripheral margin. Fiesthamel gave the length of the male as 46 mm., its full expanse as 80. The wing disk is said by him to be vivid orange and is so shown in his colored figure.

The following description of the previously undescribed female of *caternaulti* should be of service in emphasizing the marked difference in general ensemble which exists between the sexes in this genus.

Female (allotype): Maroni, French Guiana. [Acad. Nat. Sci. Phila.]

Size large (body length, 74 mm.); form robust, distinctly compressed, deep; surface of pronotum, pleura and much of more proximal section of abdomen, cribrosely impresso-punctate or punctulate, area of the lateral carinae of the pronotal dorsum supplied with linearly disposed substrumose tubercles.

Head in general form much as in males of the genus, but with its depth proportionately greater and facial line ventrad of median ocellus subvertical; fastigium with its length cephalad of the eyes and of the shallow transverse impression at its dorso-proximal base equal to three-fourths the length from the latter point caudad to the base of the occiput, greatest proximal breadth of the fastigium subequal to its length, lateral margins sigmoidally convergent to the rather broadly rounded apex, surface shallowly impressed medio-longitudinally in its distal half, as seen in profile very weakly and evenly ascending to the fastigio-facial angle, which is relatively acute, ventral line as fastigium as seen in profile straight oblique to its juncture with the nearly vertical facial line; profile of occiput low convex; frontal costa with its lateral margins well marked and carinulate, continuous and regularly diverging from briefly ventrad of the fastigio-facial angle to the clypeal suture, except for a slight constriction about the median ocellus, surface of frontal costa shallowly but distinctly excavate throughout; lateral facial carinae rather strongly carinate, much more so than the lateral borders of the frontal costa, moderately diverging ventrad; eyes prominent and weakly exserted as seen from the dorsum, as seen in profile with their basal outline elliptical, in depth slightly less than that of the infra-ocular sulcus, greatest breadth of basal outline equal to three-fifths of the depth of the outline. Antennae depressed and moderately ensiform proximad, not complete in specimen.

Pronotum appreciably compressed, greatest breadth across lateral lobes not more than three-fifths of the median length of the pronotal dorsum; cephalic margin of pronotal disk obtuse-angulate emarginate, with the

immediate angle more deeply so and subacute, caudal margin of pronotal disk acute-angulate produced; three transverse sulci intersecting the disk, prozona but slightly longer than the metazona, median carinula of disk distinct but very weak cephalad and caudad, subobsolete mesad, lateral carinae of disk eroso-strumose with scattered papillose tubercles; lateral lobes subquadrate in outline, greatest dorsal length (at lateral carinae) equal to three-fourths of the greatest depth of the lobe (as 65 to 85), the surface with a distinct but low oblique elevation extending ventro-cephalad from the principal transverse sulcus to the ventro-cephalic angle, cephalic margin of lobes subsinuately subvertical, ventro-cephalic angle obtuse-angulate, ventral margin oblique cephalad, briefly horizontal caudad and rounding over the ventro-caudal angle to the suboblique caudal margin.

Tegmina areolate coriaceous, reaching caudad as far as the narrow pregenicular section of the caudal femora, very broad in proportion, their greatest breadth contained four times in their length; costal margin expanding from base to approximately the proximal fourth, then nearly straight to about the distal eighth, where it rounds to the relatively broad, oblique, concavo-truncate apex, sutural margin very weakly arcuate, distad narrowly rounding to the distal margin; marginal field broad; anal field sharply defined. Wings when in repose reaching to the tegminal apices, when expanded with the periphery more broadly and evenly arcuate than in male individuals of the genus, greatest breadth contained nearly twice in the alar length; costal margin faintly concave except at the apex, where it narrowly rounds to the oblique truncate apex of the anterior field, apex of axillary field moderately arcuate; fenestration of axillary field marked, but with fewer cross-veins than in the males of either *octomaculata* or *bella* now before me.

Abdomen compressed, subcarinate medio-longitudinally on dorsal surface; supra-anal plate sublanceolate, compressed, medio-longitudinally sulcato-excavate, narrowing distad, apex narrowly rounded as seen from the dorsum; cerci styliform, very short acuminate; ovipositor valves relatively deep, compressed, dorsal pair with dorso-external margins sharp but entire and non-dentate, the apices of the dorsal valves not recurved as seen in profile, as seen from dorsum appreciably incurved, the dorsal surfaces appreciably excavate disto-mesad, ventral ovipositor valves shorter and slighter than the dorsal ones, hardly at all decurved distad, the ventro-external margin with a low obtuse-angulate shoulder, lateral plates relatively broad, acute at apex; subgenital plate with its distal margin transverse truncate ventrad of each ventral valve, mesad acutely produced between the ventral ovipositor valves.

Prosternal process erect, spiniform. Interspace between the mesosternal lobes moderately longitudinal and clepsydral in shape, somewhat narrower than one of the lobes; interspace between the metasternal lobes shallow, strongly transverse, somewhat broader than one of the lobes.

Cephalic and median limbs of moderate length, the femora somewhat thicker distad than proximad. Caudal femora surpassing the apices of the

alar organs but falling short of the abdominal apex, slender, in profile gently tapering to the pregenicular constriction, medio-dorsal carina with two sizes of serrulations, these present but fewer and lower on the other femoral carinae, paginal pattern low but evident, not regular, genicular lobes deep, truncato-arcuate distad; caudal tibiae with 5 to 7 spaced short spines on the externo-extensor margin, interno-extensor one with eight spines, of which the more distal ones are small, followed proximad by progressively longer ones, the two longest about three times as long as the tibial thickness, and finally with the two proximal spines developed, as is characteristic of the genus, into lamellate acute and apically spiniform lobes.

Length of body, 74.0 mm.; length of exposed dorsum of head, 10.0; length of fastigium distad of the eyes, 4.9; median length of pronotal dorsum, 15.8; length of tegmen, 40.0; greatest breadth of tegmen, 10.0; length of wing, 36.0; greatest breadth of wing, 20.0; length of caudal femur, 35.3.

Coloration.—General tone vinaceous-rufous (of Ridgway), somewhat infuscate on the face and along the areas of the lateral carinae of the pronotal dorsum, paling to ochraceous-buff on the pleura and more proximal portions of the caudal femora.[16] Dorsum of head, pronotal disk and anal area of tegmina cinnamon to clay color; eyes cupreous; antennae tawny to russet. Tegmina with anal vein pencilled in fuscous, the humeral trunk weakly touched with the same, the base tone of the marginal and discoidal field strongly vinaceous-rufous; wings with the anterior, axillary and radiate fields, except for a fuscous margining to the latter, orange rufous, the veins largely pencilled in russet. Caudal tibiae cocao brown to burnt umber, paler proximad, darker distad.

Aeolacris bella Rehn. Plate I, fig. 3; pl. II, fig. 6.

1909. *Aeolacris bella* Rehn, Proc. U. S. Nat. Mus., xxxvi, p. 114, figs. 3-5. [♂; Rio Purus [, Amazonas], Brazil.]

Brazil: Rio Purus; 1 ♂ (paratype); [A.N.S.P.].

Certain of the features originally given as diagnostic for this species we now know are without value, although *bella* is a very clearly defined species, and while more nearly related to *caternaulti* than to *octomaculata*, it has numerous points of difference from both, as set forth in the preceding key. Its habitat is roughly between those of the other two species, and structurally it has broader tegmina, in the male sex, than in either of the others, although the apex of these organs is nearer as in *caternaulti*, yet the wings in the shape of their apical areas are rather more like *octomaculata*, as is also true of the degree of development of the

[16] This paling may be true to desiccation, as the specimen was never eviscerated and the natural tone may have been altered in drying.

spines and lamellations on the caudal tibiae, while the acuteness of the angle of the caudal margin of the pronotal disk is less than in *octomaculata* and more as in *caternaulti*. The aciculation of the male subgenital plate is greater than in either of the other species, which are more nearly alike in this respect. The wing disk in *bella* is cadmium, varying in depth, but not orange as in the other two. The fenestration of the axillary area of the wing is broader, actually and proportionately, than in the other species.

Explanation of Figures

Plate I

Fig. 1.—*Aeolacris octomaculata* (Scudder). Male. Baños, Peru. Dorsal view. (Natural size.)

Fig. 2.—*Aeolacris caternaulti* (Fiesthamel). Female. Maroni, French Guiana. Dorsal view. (Natural size.)

Fig. 3.—*Aeolacris bella* Rehn. Male (*paratype*). Rio Purus, Amazonas, Brazil. Dorsal view. (Natural size.)

Plate II

Fig. 4.—*Aeolacris octomaculata* (Scudder). Male. Baños, Peru. Lateral view. (Natural size.)

Fig. 5.—*Aeolacris caternaulti* (Fiesthamel). Female. Maroni, French Guiana. Lateral view. (Natural size.)

Fig. 6.—*Aeolacris bella* Rehn. Male (*paratype*). Rio Purus, Amazonas, Brazil. Lateral view. (Natural size.)

REHN—GENUS AEOLACRIS

REHN—GENUS AEOLACRIS

A NEW SUBGENUS, TWO NEW SPECIES AND ONE NEW SUBSPECIES OF MICROTYLOPTERYX

(ORTHOPTERA; ACRIDIDAE; CYRTACANTHACRIDINAE)

BY JAMES A. G. REHN

Curator of Insects, Academy of Natural Sciences of Philadelphia

The genus *Microtylopteryx* was erected by the author in 1905,[1] with *M. hebardi* Rehn as the type species. In a subsequent paper [2] the author published a revision of the species of the genus, recognizing two species-groups, which he termed the Fusiformis Group and the Hebardi Group. There are now before me two undescribed species of the genus, both belonging to the Fusiformis Group, and a previously unrecognized subspecies of *M. hebardi*, which belongs to the other major component of the genus, as well as all the type material and moderate series of the previous known forms.

It is now clearly evident that the two categories, previously regarded as species-groups, constitute valid subgenera, and I am here proposing the name *Tristanacris*,[3] with the type species *Microtylopteryx fusiformis* Rehn,[4] for the entity previously called the "Fusiformis Group" of the genus, and which was well characterized in the key published in 1929.[5]

The previously known species are all natives of Costa Rica or Panama, those of the subgenus *Tristanacris* of Costa Rica alone. The two species here described carry the distribution of the latter

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[1] Proc. Acad. Nat. Sci. Phila., 1905, p. 448.

[2] Trans. Amer. Entom. Soc., LV, pp. 46-59, pl. V, figs. 1-15 (1929).

[3] In memory of the late Prof. J. Fidel Tristán, friend and companion on many happy field trips in his native Costa Rica, and discerning student of the biota of that interesting land.

[4] Proc. Acad. Nat. Sci. Phila., 1905, p. 451, fig. 43 [♂ ; ♀ ; Carillo, Costa Rica].

[5] Trans. Amer. Entom. Soc., LV, p. 48 (1929).

subgenus, and also of the genus, considerably to the northward, to the lowland tropical forest along the north coast of Honduras (*worthi*) and the Sierra Madre del Sur of the Pacific side of the state of Chiapas, Mexico (*chiapensis*). Thus the genus is now known to range from the Canal Zone of Panama north almost to the Isthmus of Tehuantepec, in common with many other genera, testifying to the relative unity of the Central American biota as contrasted with that of Mexico north of the ancient marine portal of Tehuantepec on one hand, and that of South America beyond the so-called " Panama fault " on the other.

The two new species here described belong to the subgenus *Tristanacris*, but in both the fastigium, as seen from the dorsum, is broader at its base and less produced than in any other form, and further in both, the caudal femora are less bullate in both dorsal and lateral aspects than in any other members of the subgenus. Each has other distinctive characters as set forth below, but collectively they can at once be distinguished by the fastigial proportions.

A previously unpublished record for one of the previously known species has been appended to encompass all available records for the genus.

Microtylopteryx (Tristanacris) chiapensis new species Figs. 1, 5 and 6.

As to the fastigial feature mentioned above, in this species that area is definitely broader at its base than its length cephalad of the eyes, its outline being slightly broader than rectangulate as seen from the dorsum. The male cerci are much more recurved dorsad than in *M.* (*T.*) *fusiformis*, or *M.* (*T.*) *worthi*, here described, having their nearest approach in curvature in those of the same sex of *M.* (*T.*) *tristani*, from Costa Rican uplands,[6] which species, however, differs in a number of respects, such as fastigial form and more robust caudal femora. From *M.* (*T.*) *worthi* the present species can be distinguished at once by its more normal development of the tegmina, the somewhat heavier antennae and less attenuate caudal femora.

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[6] Trans. Amer. Entom. Soc., LV, p. 55, pl. V, figs. 1, 2, 10, 14 and 15 (1929). [♂ (*type*), ♀ ; La Palma, between the volcanoes of Irazú and Barba, Costa Rica, elev. 5000 feet.]

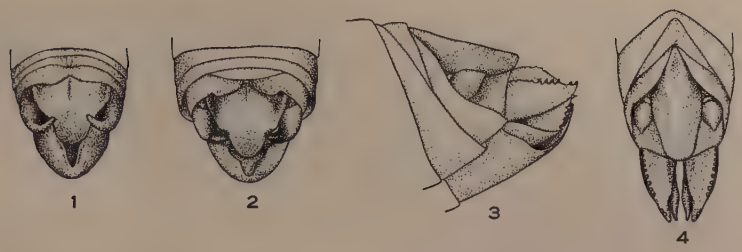

Fig. 1.—*Microtylopteryx chiapensis* new species. Male (*type*). Vergel, Chiapas, Mexico. Dorsal view of apex of abdomen. (Greatly enlarged.) Fig. 2.—*Microtylopteryx worthi* new species. Male (*type*). Lancetilla, Honduras. Dorsal view of apex of abdomen. (Greatly enlarged.) Fig. 3.—*Microtylopteryx worthi* new species. Female (*allotype*). Lancetilla, Honduras. Lateral view of apex of abdomen. (Greatly enlarged.) Fig. 4.—*Microtylopteryx worthi* new species. Female (*allotype*). Lancetilla, Honduras. Dorsal view of apex of abdomen. (Greatly enlarged.)

Type.—♂; Vergel, Sierra Madre del Sur. Chiapas, Mexico.[7] Elevation, 800 meters. June 12, 1935. (A. Dampf.) [Academy of Natural Sciences of Philadelphia. Type no. 5789.]

Size average for the subgenus (length of body, 13.8 mm.); form as a whole very similar to that of *fusiformis*; surface texture of the areas with impressed puncta having the same less densely indicated than in the male sex of *fusiformis*, this especially evident on the dorsal surface of the caudal femora.

Head as seen in cephalic aspect somewhat narrower than in the same sex of *fusiformis*, the greatest breadth across the genae in that view being as 7 to depth of head as 10 from dorsum of fastigium to clypeo-labral suture, the same ratio in *fusiformis* being 8 to 10, although the outline of the eyes in the same aspect is very similar, but somewhat different in profile, as shown beyond; fastigium as seen from the dorsum with its outline slightly broader and more obtuse than a right angle, the lateral sections of the outline not noticeably concave as they are in *fusiformis*, the length of the fastigium as seen from the dorsum distad of the least interocular space as 11 to 20 for the greatest proximal breadth of the fastigium, its dorsal surface with an hour-glass-shaped pattern of carinulae, the cephalic section of which bears an additional low medio-longitudinal carinula which passes ventro-cephalad between the raised fastigial borders found in the forms of this genus, in profile the fastigium has its dorsal outline more declivent ventro-cephalad than in *fusiformis*, and its apex more broadly

[7] Located on one of the head streams of the Rio Cintalapa (Rio Grijalva drainage). Position, 93° 55′ W., 16° 36′ N.

rounded in the same view; interocular space of vertex equal to three-fifths of greatest fastigial breadth (as 12 to 20); facial profile essentially as in *fusiformis* except for the broader rounding dorsad; frontal costa more clearly evident ventrad on face than in male of *fusiformis*, while partly interrupted its margins being traceable to the supra-clypeal suture, its median sulciform impression more strongly marked than in *fusiformis*, lateral facial carinae distinctly more evident, continuous and cariniform than in *fusiformis*, ventral portion of genae less coarsely punctate; eyes in basal outline somewhat broader ovate than in *fusiformis*, the greatest breadth being contained approximately 1.4 times in the depth (23 to 32) and over 1.5 times (25 to 38) in *fusiformis*. Antennae much as in *fusiformis* but as a whole slightly shorter and stouter, this also evident on comparison of individual articles.

Pronotum very similar to that of the male of *fusiformis*, but differing somewhat in the cephalic margin of the disk being but weakly produced mesad and with the median emargination of the same shallow and weak, while the caudal margin of the disk is as a whole much more shallowly emarginate, except for the median angulate emargination being almost subtruncate; in profile the dorsal outline has the caudal elevation lower, much less marked and more rounded than in *fusiformis*; lateral lobes with the glabrous more dorsal section less highly polished than in *fusiformis*, while the more ventral section has the puncta smaller and less excavate and the intervening surface less substrumose.

Tegmina of the same pattern and general proportions as in *fusiformis*, reaching to the distal margin of the proximal abdominal tergite, the proximal section broader than in *fusiformis*, being equal in breadth to half of the spatulate more distal section, instead of not quite a third as in *fusiformis*.

Ultimate abdominal tergite with the surface in the usual position of the furcula developed into very broad but shallow lobulations, much as in *fusiformis* but broader, reaching laterad as far as the lateral margins of the supra-anal plate, the free margins somewhat thickened, as in *fusiformis*, but not decurved as in that form; supra-anal plate much as in *fusiformis* but somewhat broader proximad and less trigonal proportionately; cerci with general pattern as in *fusiformis*, but distal lamellate section is more sharply and abruptly reflexed dorso-proximad as a flattened distally transverse-truncate plate, the more proximal section of the cerci essentially as in *fusiformis*; subgenital plate of the compressed type seen in the male of the compared form.

Prosternal process a low and weak, subconical protuberance, distinctly smaller and less evident than in *fusiformis*. Interspace between the mesosternal lobes subquadrate, slightly transverse, faintly narrowing caudad, subequal in breadth to one of the mesosternal lobes; interspace between metasternal lobes not quite half that between the mesosternal lobes.

Cephalic and median limbs slightly longer and more slender than in the male of *fusiformis*; caudal femora in general pattern much as in the male

of *fusiformis* but in profile slightly more slender and proportionately not quite as deep, the greatest depth contained 3.7 times in the length (as 47 to 175), as against 3.4 in *fusiformis*, while as seen from the dorsum the caudal femora are less inflated, consequently thinner, and the medio-dorsal carina is much more weakly serrulate; caudad tibiae with six external and eight to nine internal spines on the extensor margins. Caudal tarsi as a whole somewhat longer than in *fusiformis*, the metatarsus subequal in length to the distal tarsal article, instead of appreciably shorter, as in *fusiformis*.

Measurements of type.—Length of body, 13.8 mm.; median length of pronotum, 3.4; length of tegmen, 2.77; length of caudal femur, 9.6.

Coloration.—Pattern the same as in the male sex of *M.* (*T.*) *fusiformis* with the following exceptions: the genae, the lateral lobes of the pronotum and the pleura are more deeply and solidly shining fuscous, that of the genae quite sharply relieved cephalad by a narrow buffy area along the lateral facial carinae; caudal faces of the cephalic and median femora heavily and contrastingly fuscous, also cloudings of the same present on the cephalic faces of the same femora, while the cephalic and median tibiae are blotched with the same color, particularly preapically; tegmina touched with fuscous medio-longitudinally in distal section; exposed section of lateral polished area of metanotum fuscous similar to the lateral areas of the abdominal tergites; caudal femora with external pagina and ventral faces solidly brownish fuscous, dorsad uniformly and contrastingly buffy except for two subcircular longitudinally disposed small spots of fuscous very near the proximal extremity, internal face of caudal femora similarly fuscous except for a pale lining along the ventro-internal carina and a pale preapical annulus like that of *fusiformis*; caudal tibiae fuscous with a pale postgenicular pale annulus as in *fusiformis*; ventral surface fuscous except for buffy peripheral borderings and paired circular dots on at least the four proximal sternites.

The type is unique.

Microtylopteryx (Tristanacris) worthi [8] new species Figs. 1-4, 7-10.

In addition to the very short and broad fastigium, which in outline is obtuse-angulate in both sexes as seen from the dorsum, this species can at once be distinguished in both sexes by the very short tegmina, which do not surpass the caudal margin of the metanotum, in this being unique in the genus. The male cerci are sharply recurved distad, as in *fusiformis*, and thus differ appreciably from those of *M.* (*T.*) *chiapensis*. The fastigium is blunter and shorter proportionately in this species than in any other member of the subgenus.

[8] In honor of Dr. C. Brooke Worth, of the Rockefeller Institute, who was one of my companions on the 1930 expedition which secured this species.

Type.— ♂ ; Lancetilla, near Tela, Atlantida District, Honduras. Elevation, 100-800 feet (in rain forest). September 3, 1930. (Honduras Expedition; J. A. G. Rehn.) [Academy of Natural Sciences of Philadelphia, Type no. 5790.]

Size larger than in the same sex of *M.* (*T.*) *chiapensis* (length of body, 16.6 mm.); general form as in the other members of the subgenus *Tristanacris*; surface texture with the impressed puncta more as in *chiapensis* than in *fusiformis*, that is, less deeply excavate individually and less strongly marked on the abdominal dorsum than in the latter, the glabrous areas on the lateral lobes of the pronotum and on the lateral aspects of the abdomen less sharply delimited from the punctate dorsal surfaces.

Head as seen from the dorsum with its general proportions as in *M.* (*T.*) *fusiformis*, in cephalic aspect the greatest breadth across the genae is as 8 to depth of head as 11 from dorsum of fastigium to clypeolabial suture, outline of eyes in cephalic aspect essentially as in *chiapensis* and *fusiformis;* fastigium as seen from the dorsum shorter and broader than in *fusiformis*, the ratio of greatest breadth to length cephalad of the least interocular space being as width 22 to length 10, while in *fusiformis* the length is 13 to width of 22, the converging lateral arms of the fastigial margin as seen from the dorsum moderately concave, slightly more so than in *chiapensis* and much less so than in *fusiformis*, dorsal surface of fastigium virtually lacking a median carinula but coarsely impresso-punctate, this sharply contrasted with the interocular area, which is smooth with a low rounded medio-longitudinal carinula, this area smoother than in either *fusiformis* or *chiapensis*, while the contrasted dorsum of the occiput has caudad-diverging areas of impressed punctations somewhat less emphasized than in *chiapensis* and much less so than in *fusiformis*, in profile the fastigio-facial angle is even more broadly rounded than in *chiapensis* and quite different from the much more produced angulation of *fusiformis*; interocular space of vertex somewhat broader than in either of the compared forms, being nearly equal to seven-tenths of the greatest breadth of the fastigium (as 15 to 22); facial profile as in related forms except for that of the fastigio-facial angle; frontal costa somewhat broader and shallower than in *chiapensis*, especially ventrad of the median ocellus, lateral carinae of costa not as well defined ventrad as in *chiapensis* but there more evident than in *fusiformis*, impressed puncta of frontal costa and adjacent face not as deeply impressed as in the compared forms, lateral facial carinae distinctly less marked than in *chiapensis* but slightly more evident than in *fusiformis*, ventral portion of genae with puncta much as in *chiapensis*; eyes in basal outline somewhat broader than in *fusiformis* or *chiapensis*, the greatest breadth contained approximately 1.35 times in the depth (as 28 to 38). Antennae not quite complete in type, but articles present are individually distinctly longer than in *chiapensis* and even slightly longer than in *fusiformis*.

Pronotum with its general proportions, as seen from the dorsum, as in *M. chiapensis,* cephalic margin of dorsum of pronotum somewhat more angulately produced than in *chiapensis* but less so than in *fusiformis,* the median notch in the same margin no more pronounced than in *chiapensis,* caudal margin of pronotal dorsum hardly at all concave, almost subtruncate with the median notch very shallow, in profile the dorsal line of the pronotum is subconvex on the prozonal section, straight caudad of the principal sulcus, in its profile thus somewhat different from *chiapensis* or *fusiformis,* lateral shoulders of the pronotal disk as in related species but less clearly marked; lateral lobes more similar to those of *chiapensis* than of *fusiformis.*

Tegmina not quite reaching to the distal margin of the metanotum, simple slip-like structures of nearly subequal breadth throughout, and quite different in outline from the broad spatulate tegmina of *fusiformis* and *chiapensis,* their greatest breadth approximately one-third of their length, apices broadly rounded.

Abdomen with tergites distad of the proximal one having the polished lateral sections less sharply defined from the impresso-punctate dorsal areas than in either *chiapensis* or *fusiformis*; ultimate abdominal tergite cut away mesad in a broad and shallow V-emargination, the only indication of furcula being very narrow, bevelled and oblique borders to the tergite laterad of the median emargination; supra-anal plate trigonal in outline, its greatest proximal breadth slightly greater than its median length (as 20 to 18), proximal five-eighths of lateral margins straight oblique convergent with an elevated thickened cingulate rim, distad of which the apical portion of the outline is broadly rounded, without any elevated rim and supplied with a few chaetiform hairs projecting distad; cerci with proximal half tapering subcylindrical, as seen in profile with distal section rectangulately bent dorsad and surface there deplanate cephalad and caudad, so they are transversely sublamellate in the upcurved distal section with an inward tilt to that portion, as seen in cephalic aspect the apical margin is obtusely rounded, the whole cercus in length falling distinctly short of the apex of the supra-anal plate, in fact reaching very slightly distad of the end of the marginal angulation of the lateral sections of the supra-anal plate; infra-cercal plates slightly exceeding the apex of the supra-anal plate; subgenital plate much as in *fusiformis* but somewhat fuller and less compressed; ultimate sternite somewhat broader and slightly more bulbous than in *fusiformis.*

Prosternal process acuminately spiniform, as in *M.* (*T.*) *fusiformis.* Interspace between the mesosternal lobes quadrate, very faintly narrowing caudad, equal in breadth to one of the mesosternal lobes; interval between the mestasternal lobes slightly less than half that between the mesosternal ones.

Cephalic and median femora slightly longer and distinctly more slender than in *fusiformis.* Caudal femora longer and more slender than in *fusiformis,* the greatest depth contained four times in the length (as 17 to 68), also as seen from dorsum with their inflation very much less, their dorso-external face much narrower and less deeply and thickly impresso-punctate,

while the ventro-external face is also much narrower and more clearly cut off from the paginal surface by a carina than in *fusiformis*; caudal tibiae with six external and nine internal spines. Caudal tarsi in proportion to the limbs as a whole more elongate than in *fusiformis*.

Allotype.—♀; same data as type except September 5, 1930. [Academy of Natural Science of Philadelphia.]

The following features are of difference from the same sex of *M.* (*T.*) *fusiformis fusiformis* Rehn.[9]

General size and proportions very similar; surface very similar but less deeply and thickly punctate in some areas.

Head with the fastigium much less produced, transversely obtuse-angulate in outline, its greatest proximal breadth but one-third of its median length cephalad of the eyes, instead of approximately two-thirds as in the same sex of *f. fusiformis*, converging lateral margins, as seen from the dorsum, shallowly concave, apex shallowly divided but as in related species the sulcation is indicated for but a short distance on the fastigial dorsum, which is punctulately rugulose as in related forms; interocular space two-thirds as broad as the fastigium, the occipital median carinula carried forward over this area, and there separating well-marked subquadrate lateral smooth areas of the interocular space; fastigio-facial angle as seen in profile less produced and as a whole rectangulate with the dorsal outline of the fastigium slightly declivent and the immediate angle narrowly rounded; facial line straight and moderately retreating, not at all shallowly concave as in *f. fusiformis*; frontal costa much as in *f. fusiformis* but slightly broader and more subequal in breadth, the degree of elevation of the marginal carinae and the strength of the impressed punctations of the sulcus essentially the same; lateral facial carinae more evident and continuous than in *f. fusiformis*; eyes slightly more prominent as seen in cephalic aspect than in *f. fusiformis*, in basal outline more broad ovate and less elliptical, the greatest breadth of the outline being slightly more than two-thirds of its greatest depth (as 11 to 15) instead of exactly two-thirds (as 10 to 15) as in *f. fusiformis*. Antennae appreciably longer than in *f fusiformis*, the individual articles more elongate.

Pronotum as a whole very similar to that of the female of *f. fusiformis*; caudal margin of disk with median notch slightly more emphasized and deeper, in profile the dorsal outline of the prozona is more evenly low arcuate, the impression of the principal transverse sulcus is more pronounced, the line of the lateral shoulders, as seen in profile, is more evenly arcuate throughout, and the lateral lobes are somewhat more longitudinal as seen in lateral aspect.

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[9] Direct comparison has been made with a female individual of the latter form from La Emilia, near Guápiles, Costa Rica, a locality but a limited number of miles from, and in the same conditions and at nearly the same elevation as, Carillo, the type locality, a community which has long been completely abandoned.

Tegmina greatly reduced, being narrow linear lobiform slips with their apices falling short of the distal margin of the metanotum, their greatest breadth about a fifth of their length and the whole entirely lacking the spatulate outline seen in most of the forms of the genus.

Metanotum with a marked ovoid polished area laterad which is evident dorsad of the tegmina, instead of being hidden by the latter as in *f. fusiformis*; medio-caudal point of distal margin less compressed and less elevated than in *f. fusiformis.*

Abdomen with the tergites distad of the proximal one having the line of juncture of the deeply punctate dorsal sections and the polished lateral ones as a whole more longitudinal and parallel to the dorsal outline of the abdominal profile than in *f. fusiformis,* where on the individual tergites the line of juncture is more oblique; supra-anal plate strongly longitudinal, deeply inserted in the acute-angulate median flexure of the ultimate tergite, yet broader inter-cercally than in *f. fusiformis* and with the outline of the extremity more semi-ovate, and as in related forms provided with a number of bristles, these also present on the cerci; cerci of the same very short, thick, subtrigonal outline seen in the female of *f. fusiformis*; ovipositor jaws of the same very short and thick type seen in *f. fusiformis,* the dorsal pair even thicker than in the latter and with the diastema between the apical group of spines on their dorso-external margin and those more proximad on the same margin less extensive than in *f. fusiformis,* ventral ovipositor valves much as in latter species; subgenital plate with its median process proportionately broader at the base than in *f. fusiformis.*

Interspaces between the mesosternal and metasternal lobes somewhat broader than in *f. fusiformis.*

Cephalic and median femora slightly longer and more slender than in the female of *f. fusiformis*; caudal femora more slender, not as deep and by no means as inflated as seen from the dorsum, their greatest depth contained somewhat more than 3.5 times in their length (as 21 to 75), genicular extremity in proportion more slender than in *f. fusiformis,* and the same area in profile less strongly arcuate in dorsal outline than in the latter, dorso-external carina subobsolete when compared with that of *f. fusiformis,* dorso-external face narrower; caudal tibiae somewhat more slender than in *f. fusiformis,* armed with six external and eight internal spines; caudal tarsi as a whole slightly more slender than in the same sex of *f. fusiformis.*

MEASUREMENTS (*in millimeters*)

	Length of body	Median length of pronotum	Length of tegmen	Length of caudal femur
♂, Lancetilla, *type*	16.6	4.5	1.14	11.7
♂, Lancetilla, *paratype*	17.1	4.4	1.46	11.2
♀, Lancetilla, *allotype*	21.1	5.0	2.25	12.7
♀, Lancetilla, *paratype*	21.5	5.0	1.95	13.3

Coloration.—Color pattern and color tones almost exactly as in the here-described *M.* (*T.*) *chiapensis* except that the cephalic and median femora and tibiae have the fuscous areas more extensive and more solid, while the caudal femora have their internal face solidly fuscous without any indication of a preapical paler annulus; their ventral body surface is solidly fuscous except for several subobsolete cloudings cephalad on the meso-metasternum.

Bionomics.—This species, like the other members of the genus, is an inhabitant of the undergrowth of heavy forest, in the case of the present species undisturbed rain forest, and at elevations of between one and eight hundred feet above sea-level in the Sierra Pija of northern Honduras. An account of the general conditions in the rain forest on the north face of the coastal Sierra Pija immediately about Lancetilla has already been presented by the author.[10] In this situation *M. worthi* was by no means numerous, the few individuals secured being all seen, and these were taken on four different days of the eleven spent in the preferred environment. Each day's total was but a single specimen, and the species was much scarcer than its relatives, i.e. *fusiformis, tristani* and *talamancae* were in their respective areas in Costa Rica in field work done by me in 1923 and 1927. The field notes made on the days on which *worthi* was collected (i.e. September 3, 4, 5 and 9) are as follows: "in lower foliage in sunlight hole in rain forest" (3rd); "in low ground cover at 600 feet" (4th); "from upper surface of low shrub foliage, no other seen" (5th); "one all seen and taken on low foliage" (9th). Notes made in the field as to the habits of three very distinctive rain forest undergrowth inhabiting genera, i.e. *Leptomerinthoprora, Rhachicreagra,* and *Microtylopteryx,* are of interest in connection with the latter genus. These state: "*Microtylopteryx* keeps to the upper surface of the leaves of the shrubs of medium height it likes, jumping far and with little effort, while *Rhachicreagra* keeps in taller shrubbery on the tops of the leaves or on the upper stem or stalks of the plant. [The latter genus] is more sluggish and jumps with a far greater effort."

Material examined: 4; 2 ♂, 2 ♀.

HONDURAS: Lancetilla, Atlantida District; IX, 3, 4, 5 and 9, 1930; (Honduras Expedition: J. A. G Rehn); 2 ♂ (*type* and *paratype*), 2 ♀ *allotype* and *paratype*); [Academy of Natural Sciences of Philadelphia].

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[10] In "A Naturalist in Honduras." Bull. Pan Amer. Union, LXVI, pp. 390-400 (1932). Lancetilla conditions are discussed on pages 399-400.

Microtylopteryx hebardi caligo [11] new subspecies

Differing from *M. h. hebardi* Rehn, of lower levels in eastern Costa Rica, in the somewhat less prominent eyes, as seen from the dorsum and in cephalic aspect, and in the more obliquely declivent dorsal profile of the fastigio-facial angle, which latter is slightly more rounded in the same view. This subspecies probably intergrades with typical *h. hebardi* at elevations between those at which the latter occurs (1000-1500 feet) and that of the type locality of *h. caligo* (4900-5000 feet).

Type.—♂; La Palma, between Irazú and Barba, Costa Rica.[12] Elevation, 1500 meters. 1929. (Valerio.) [Academy of Natural Sciences of Philadelphia, Type no. 5791.]

When compared with material of *M. hebardi hebardi* from the type locality (Carillo, Costa Rica) and nearby La Emilia, Costa Rica, seen to differ chiefly in the following respects:

Head as seen in profile with the dorsal outline of the fastigium appreciably more declivent cephalad and more broadly rounding over the fastigio-facial angles; eyes as seen from the dorsum somewhat less protuberant than in *h. hebardi*, and also as seen in cephalic aspect; head as a whole proportionately somewhat broader across the genae than in *h. hebardi*. Male genitalia as in *M. h. hebardi*. Caudal tarsi as a whole somewhat longer than in *M. h. hebardi*, this chiefly due to the proportionately greater length of the metatarsus.

Allotype.—♀; same data as type. [Academy of Natural Sciences of Philadelphia.]

Differing from female material of *h. hebardi* from the same localities as the males compared above, in the same features as there indicated.[13]

Measurements (in millimeters).—♂ (*type*); length of body, 18.0 mm.; median length of pronotum, 4.0; length of tegmen, 2.93; length of caudal femur, 13.8. ♀ (*allotype*); median length of pronotum, 4.7; length of tegmen, —[14]; length of caudal femur, 14.8.

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[11] I.e. *mist, vapor, fog,* in allusion to the cloud forest conditions at the type locality.

[12] For a description of this locality, which has been examined by the author on two occasions, see Yearbook, Acad. Nat. Sci. Phila., 1927, pp. 27-28.

[13] Unfortunately the available female individual of this subspecies is imperfect and was considerably damaged by pests before reaching my hands. The apex of the abdomen being lacking, I am unable to give the body length. However, those differential features of the head described for the male sex are equally marked in the allotype.

[14] Damaged.

Coloration.—Differing in no noteworthy respect from that of *M. h. hebardi.*

Remarks.—A single male paratype, bearing the same data as the type and allotype, has also been examined.

Material examined: 3; 2 ♂, 1 ♀.

Costa Rica; La Palma, 1929; (M. Valerio); 2 ♂ (*type* and *paratype*), 1 ♀ (*allotype*); [A.N.S.P.].

Additional Record of Previously-known Species

Microtylopteryx fusiformis fusiformis Rehn

Costa Rica: Chitaría,[15] 500 meters elevation; 1929; (M. Valerio): 4 ♂; [A.N.S.P.].

These specimens are inseparable from individuals of the same sex from La Emilia, near Guápiles, Costa Rica. Previously records of this form from the same general area were of its capture at Juan Viñas (Bruner, 1908 and Rehn, 1929) and Pejivalle (Rehn, 1929).

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[15] This locality is 1.5 miles SE. of Peralta (below Turrialba, across the Rio Reventazón), and about 14 miles NE. of Pejivalle. Its position is approximately 9° 57′ N., 83° 35′ W.

Explanation of Plate I

Fig. 5.—*Microtylopteryx chiapensis* new species. Male (*type*). Vergel, Chiapas, Mexico. Dorsal view. (X 2⅓.)

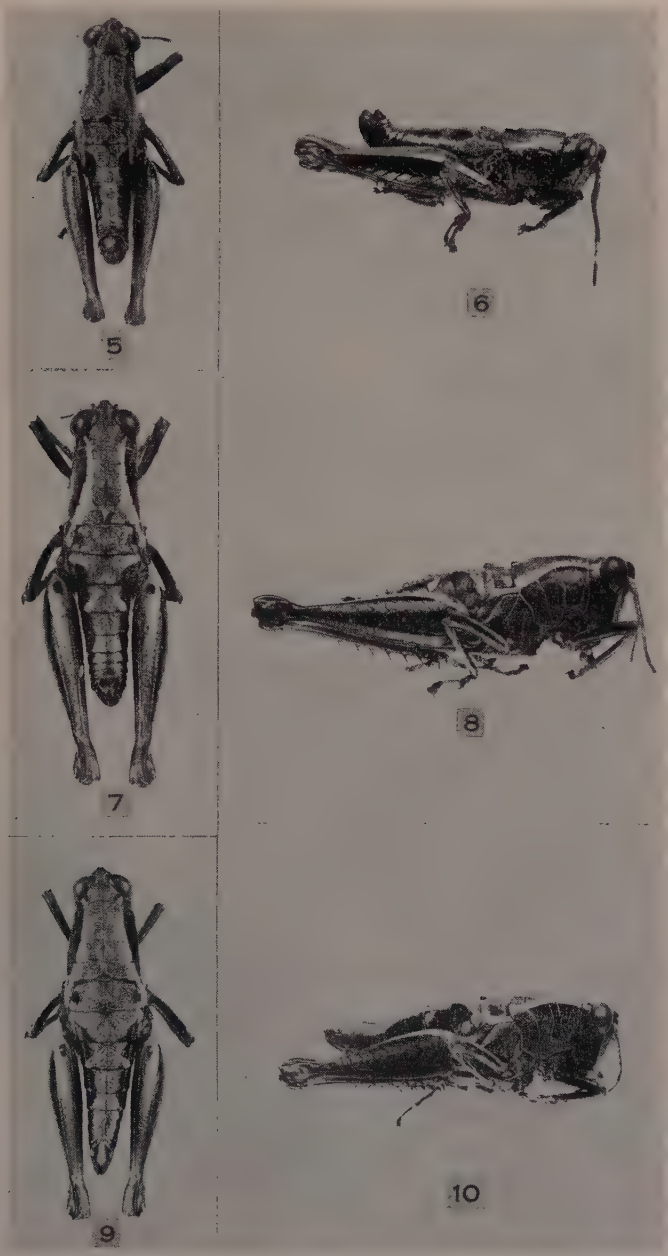
Fig. 6.—*Microtylopteryx chiapensis* new species. Male (*type*). Vergel, Chiapas, Mexico. Lateral view. (X 2⅓.)

Fig. 7.—*Microtylopteryx worthi* new species. Male (*type*). Lancetilla, Honduras. Dorsal view. (X 2⅕.)

Fig. 8.—*Microtylopteryx worthi* new species. Male (*type*). Lancetilla, Honduras. Lateral view. (X 2⅕.)

Fig. 9.—*Microtylopteryx worthi* new species. Female (*allotype*). Lancetilla, Honduras. Dorsal view. (X 2⅕.)

Fig. 10.—*Microtylopteryx worthi* new species. Female (*allotype*). Lancetilla, Honduras. Laterial view. (X 2⅕.)



REHN—MICROTYLOPTERYX

THE FEMALE SEX OF MOHAVACRIS
(ORTHOPTERA; ACRIDOIDEA; EUMASTACIDAE)

BY JAMES A. G. REHN

Curator of Insects, Academy of Natural Sciences of Philadelphia

In 1948 I described the most aberrant eumastacid genus *Mohavacris*, and the species *M. timberlakei*, from the basis of a single male, taken along the southern border of the Mohave Desert in southern California.[1] The exact locality at which the type was taken was given by Dr. P. H. Timberlake, who with Mrs. Timberlake collected the specimen, as along highway 138, " near the north base of the San Gabriel Mountains in Los Angeles County, but near the San Bernandino line." The date of its capture was April 20, 1947, and it was not swept from vegetation, as is the usual method of capture of *Morsea* and *Psychomastax*, other Californian genera of the family. As stated in 1948 a study of topographic charts indicated that the type was probably taken a few miles east of the little settlement of Llano, and near the course of Rock Creek wash. On May 3, 1954 I spent quite a few hours in the general area where the type of *Mohavacris* was secured, both actively beating vegetation and examining the ground surface, but saw no trace of the genus, and concluded from experience of several preceding weeks in the Colorado and Yuma Deserts that in the Mohave, at least in 1954, material was definitely less advanced than in southwestern Arizona and lower levels in more southern California, and that this in a measure was responsible for my failure to find any trace of *Mohavacris*, or certain other desiderata. Whether this assumption was correct is still uncertain.

In recent weeks, however, I was agreeably surprised and greatly pleased to receive from Dr. Timberlake the first female of *Mohavacris* to be reported. It is a female in perfect condition, taken at Desert Springs, in the southern portion of the Mohave Desert, southern California, May 19, 1954, by Dr. Paul D. Hurd, Jr. This specimen was taken by sweeping after it became rather dark in the evening.

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[1] Proc. Acad. Nat. Sci. Phila., C, p. 17 (1948).

In consequence I am in the happy position of being able to add to the earlier description of the genus *Mohavacris* certain features of the female sex worthy of note, and also to describe the allotypic female of *M. timberlakei.* It is probable the genus is chiefly nocturnal, or at least, crepuscular, in its activities, as appears to be true of *Tanaocerus*, its only near relative.

MOHAVACRIS Rehn

1948. Proc. Acad. Nat. Sci. Phila., C, p. 17.

The following features of generic importance have been drawn from the female and are supplementary to those already given on the basis of the male sex.

General form more elongate than in male, equally subcompressed. Fastigium excavate but less deeply so than in male, dorsal portion of facial outline equally produced but more arcuate as seen in profile, eyes not as prominent as in male, somewhat smaller proportionately; antennae when extended caudad falling but little short of the apices of the caudal femora, otherwise as described for male, the distal articles slightly deplanate. Pronotum with lateral carinae of disk not as strongly marked as in the male, median carina lobato-cristate caudad as in the male; lateral lobes with their ventral margin more sinuate than in the male. Prosternum even more strongly transverse than in the male, subrectangulate with the cephalic and caudal margins subparallel, foveolae as in the male. Mediolongitudinal dorsal abdominal crest more decided than in the male, this especially pronounced distad; female supra-anal plate acute trigonal; cerci of female very short and simple; dorsal ovipositor valves acuminate and not recurved as seen in profile, dorsal surface deplanate and rugose, external and internal dorsal margins and a median ridge dentate, ventral valves faintly decurving distad, external margin with a marked dentiform shoulder, ventral surfaces of ventral valves distad somewhat concave;[2] distal margin of subgenital plate arcuate. Caudal femora reaching to the base of the cerci.

Mohavacris timberlakei Rehn Plate I, figs. 1 and 2.

1948. Proc. Acad. Nat. Sci. Phila., C, p. 18, figs. 9-11, 17-18.

Allotype.— ♀ ; Desert Springs, Mohave Desert, Los Angeles Co., California.[3] May 19, 1954. (Dr. Paul D. Hurd, Jr., sweeping.) [Academy of Natural Sciences of Philadelphia.]

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[2] The general structure of the ovipositor valves is very much as in *Tanaocerus*, although the general body form and many other developments are widely different.

[3] Dr. Timberlake advises me this locality is "about 4 or 5 miles from the type locality."

Size medium; form moderately compressed; surface rugosities much as in male, consisting of numerous aciculate asperities, often arranged linearly in a longitudinal disposition.

Head much as in male but with eyes much less protuberant in both dorsal and cephalic aspects, genae as seen in latter view arcuately broadening ventrad from the ventral border of eyes, the greatest breadth across genae being 1.2 times that across eyes; fastigium with its details as seen from dorsum as in male but the whole is slightly broader; dorsal portion of facial profile as a whole more broadly and regularly arcuate, infra-ocellar section of the facial profile straighter and more vertical than in the male, more sharply marked off from the produced dorsal section of the profile; eyes with basal outline more ovoid and less ovate than in the male, weakly narrowing dorsad, greatest breadth of outline equal to seven-eighths of depth, the latter contained 1.5 times in the infra-ocular depth of the genae. Antennae of the same general character as in the male but shorter, not reaching to the apices of the caudal femora, the individual articles, while still exceptionally long for an acridid, are shorter than in the male.

Pronotum as described above in supplementary generic features, also with the median carina of the disk as a whole more elevated than in the male, and its "rudder-like" caudal elevation higher than in the male, and involving the whole caudal half of the carina; lateral lobes with the ventral margin slightly more declivent caudad than in the male.

Abdominal features as given above in the supplementary generic comments.

Cephalic femora with their length subequal to that of the median carina of the pronotum, appreciably stouter than in the male, carination as in the latter; median femora somewhat shorter than the cephalic pair, also appreciably stouter than in the male. Caudal femora reaching to the base of the cerci, their greatest depth, at proximal fifth, equal to one-fifth of their length (as 15 to 75), carination and paginal pattern as in male; caudal tibiae with spination as described for the male sex; caudal tarsi about one-fourth as long as the caudal tibiae (as 20 to 80), second tarsal article two-fifths as long as the proximal one.

Measurements.—Length of body, 23.0 mm.; length of head, 2.21; length of antenna, 19.4; length of pronotum, 3.6; length of caudal femur, 11.8; length of caudal tibia, 12.6.

Coloration.—General coloration mottled dull browns and grays, darker in tone and more predominatingly grayish than in the male, the surface asperities fuscous to blackish, the carinulations largely more buffy, the abdomen in particular shows a very fine, close and delicate pattern of sublongitudinal and subparallel micro-lineations of fuscous, these breaking into spots on the venter of the abdomen. Ventral three-fifths of the genae washed with dull whitish, the ventral section of the lateral lobes of the pronotum rather obscurely washed with buffy; antennae lined in part longitudinally with fuscous, distad the articles are similarly narrowly fuscous subannulate.

Since preparing the preceding description there has come to my attention a very recent paper by Dr. V. M. Dirsh [4] in which that author has raised the entity to which I assigned the genera *Tanaocerus* and *Mohavacris* in 1948, from a subfamily, as created by me, to family rank. The relative standing and value of entities of this character will probably always remain on a more or less personal basis, depending upon the individual student's attitude regarding the rank of aggregations of higher than generic value. Personally I prefer the more conservative course of considering the *Tanaocerotinae* as of subfamily rank.

However, there is one aspect of Dirsh's manipulation of the name of the entity from which I differ, regardless of the face of his argument, because of its error, and the utterly unrecognized confusion such a course would cause with many hundreds of names now in current usage for families and subfamilies in many fields of zoology, and particularly in mammals both recent and fossil. Dirsh has emended the name from Tanaocerotidae, which it would be in giving it the value he proposes, to Tanaoceridae. For justification of this action he quotes paragraph 50 (1) (a) of the "Copenhagen Decisions on Zoological Nomenclature," to the effect that (quotation from Dirsh, p. 285 footnote) "a group name is to be formed by replacing the genitive termination of the name of the genus by the termination 'inae' or 'idae.'" The original International Zoological Code (1913) stated (Article 4) "The name of a family is formed by adding the ending *idae*, the name of a subfamily by adding *inae* to the stem of the name of its type genus." As the genitive of "ceras" is "ceratos," and the stem, or the root, is "cerat," the genitive termination is "os," hence the form I used in 1948 is warranted, and in conformity with many hundreds of similar combinations long current in zoology and in palaeontology. The sad aspect of the situation is that the "Copenhagen Decisions" are so inexplicit, and their actual wording in this case is so loose, it could lead to completely illogical and incorrect combinations, that could have been avoided by a closer adherence to the wording and spirit of the original Code, as well as those of other codes from which we have endeavored to get warranted, workable and consistent guides.

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[4] "Tanaoceridae and Xyronotidae: Two New Families of Acridoidea (Orthoptera)." Ann. and Mag. Nat. Hist. (12) 8, pp. 285-288. April, 1955.

Explanation of Figures

Plate I

Fig. 1.—*Mohavacris timberlakei* Rehn. Lateral view of allotypic female. Desert Springs, Mohave Desert, California. (X 2⅘.)

Fig. 2.—*Mohavacris timberlakei* Rehn. Dorsal view of allotypic female. Desert Springs, Mohave Desert, California. (X 2⅘.)

REHN—MOHAVACRIS FEMALE

STUDIES ON THE LARVAE OF DIGGER WASPS (HYMENOPTERA, SPHECIDAE). PART I: SPHECINAE [1]

BY HOWARD E. EVANS AND CHENG SHAN LIN

Cornell University, Ithaca, N. Y.

(Plates I to VIII)

This is the first of a series of papers in which the larvae of all species of North American digger wasps (Sphecidae) available to the writers will be described and figured. This part includes introductory material and the subfamily Sphecinae. Part II will cover the subfamily Nyssoninae. Subsequent parts will cover the remaining subfamilies, and the concluding section will contain a discussion of the classification and phylogeny of the Sphecidae as indicated by larval characters.

It is a curious fact that the larva of not a single species of North American Sphecidae has been adequately described up to this time. This is in marked contrast to Europe, where such workers as Grandi, Maneval, Soika, and others have described the larvae of a host of species. This is a reflection of the fact that the biologies of the European species have been much more thoroughly studied than have the North American species, for sphecid larvae can be collected only in connection with detailed biological studies. Sphecid larvae occur in nests prepared by the mother wasp, and to obtain larvae of known species one must mark the nests in the field while they are being prepared or provisioned, or bring them into the laboratory. The nests must be watched closely and the larvae preserved in a full-grown state, preferably just as they begin to spin their cocoon. Larvae taken from completed cocoons, and

[1] Many of the larvae here described were collected in the course of a research project on the comparative behavior of solitary wasps, supported by a grant from the National Science Foundation.

Completion of these studies, including preparation of the larvae for study and the making of drawings, was facilitated by a grant from the Permanent Science Fund of the American Academy of Arts and Sciences.

Acknowledgment is made to the Grace H. Griswold Fund of the Entomology Department of Cornell University for assuming the expense of engraving the plates.

particularly overwintering larvae, often show changes in body form. Adult wasps for identification must either be taken in the field as they prepare or provision the nest, or must be reared from some of the larvae. Under the circumstances it is not surprising that most of the museums in the United States have in their collections either no sphecid larvae at all, or only a few species, usually represented by very short series.

One may ask the importance of studies such as these. Identification of sphecid larvae is not often a problem, as the adults and their nests are far more readily identified than the larvae, and the larvae are never encountered away from the nests. But the fact is that the classification of the Sphecidae, one of the largest families of Hymenoptera, is far from settled, and there is no general agreement on the true relationships and phylogeny of the various subfamilies and tribes. Any information which may be brought to bear on this subject by a study of the larvae is likely to prove valuable. As yet no one, even in Europe, has attempted to bring together descriptions of the various forms in systematic fashion in order to work out their differences and similarities.

In anticipation of our conclusions, it may be stated that there are far more characters of taxonomic value in the larvae of digger wasps than had previously been appreciated, and the light they shed on the interrelationships of the various groups is considerable. The major subfamilies are readily separable by numerous well-marked larval characters, and many of the tribes are equally distinct. Most of the genera can also be defined on the basis of several characters. However, the species within a genus are often exceedingly similar; occasionally they can be clearly separated, often only doubtfully so. Nevertheless, we have described the larvae of as many species as possible, even where only doubtfully separable, in the hope of thereby ascertaining the generic characters more clearly. For the most part, the usual classification, based on adult characters, is supported (this is true of the subfamily Sphecinae, considered in this section). In other instances, certain desirable changes in the existing classification are suggested. Throughout these studies, trends in the evolution of certain characters are apparent which cannot be ignored in any over-all consideration of the phylogeny of these wasps.

Acknowledgments

Many of the larvae described in these studies were collected by the writers in the course of field work on the biology of digger wasps, chiefly in the states of New York, Kansas, and Florida. In this work we received much assistance from Carl M. Yoshimoto and from Mary Alice Evans, wife of the senior author. Karl V. Krombein, of the Entomology Research Branch, U. S. Department of Agriculture, has generously made available all the larvae collected in the course of his valuable studies on the biology of various digger wasps. James E. Gillaspy, of Twin Falls, Idaho, and Samuel S. Ristich, of Port Jefferson, N. Y., both have contributed valuable specimens. Other specimens were borrowed from various museums, particularly the U. S. National Museum and the Illinois Natural History Survey. The co-operation of all these individuals and institutions is gratefully acknowledged.

The various published papers on sphecid larva, particularly by European workers, have been consulted, and we have attempted to integrate this information into our formulation of generic, tribal, and subfamilial characters. The recent paper of C. D. Michener (1953, Univ. Kansas Sci. Bull, 35: 987-1102) on bee larvae has been useful to us in many ways; indeed, it did much to inspire the present studies.

Techniques and Procedures

Larvae which were collected by the writers were placed in Kahle's fluid; the larger larvae were injected with this fluid through the posterior end of the body. After 24 to 48 hours they were transferred to 70% alcohol, where they were stored. Adult wasps taken in association with the larvae or reared from them were identified in part by the senior author and in part by W. D. Murray (Sphecinae) and K. V. Krombein (other groups).

Descriptions of the larvae were drawn from whole specimens and from specimens in which the head capsule had been cut off, treated in potash, and mounted in glycerin in a depression slide; in some cases spiracles were also treated in this way. Such slides could be studied under magnifications up to 600X with a compound microscope; magnification of this order was in fact necessary to observe some of the details of structure which proved important.

Measurements were made with a calibrated ocular micrometer and drawings were made with the aid of a microprojector.

Descriptions of the larvae were drawn up by the senior author, while the junior author is responsible for most of the drawings. Certain facts must be borne in mind in interpreting the descriptions and drawings. First, the available larvae vary considerably in their state of preservation. Second, although as far as we know all the larvae are in the last instar, all are not necessarily fully grown; this applies particularly to laboratory-reared specimens, which often spin their cocoons prematurely. Furthermore, there is much individual and sexual variation in size in each species. Third, only very short series were available for most species.

For these reasons, we have selected a single specimen for description under each species, and have presented measurements on that specimen. Other available specimens were examined, and if any important discrepancies were noted, this information is also presented in the description. The reason for presenting absolute measurements on body parts for a single individual is that this permits comparison of the size of structures within that individual, presumably typical of the species. Ratios of various body parts may then be computed and used as taxonomic characters.

No attempt has been made to present a " complete " description of each species. Rather, one species in each tribe or subfamily has been selected for relatively detailed description; one species of each other genus in the same tribe or subfamily has been selected for a somewhat less detailed description; and finally, other species in the same genus are given very brief, comparative descriptions.

Structure and Terminology

The general characteristics of the larvae of Sphecidae have been given by Michener (1953, Univ. Kansas Sci. Bull., 35: 990), who has also presented a key to many of the families of hymenopterous larvae. The following discussion of the structure of a typical sphecid larva is presented in order to clarify the terminology used in the following pages. For the most part, we have followed Short (1952, Trans. Roy. Ent. Soc. London, 103: 27-84) and Michener.

Body.—The body is whitish, almost or entirely without sclerotized parts, and without legs or prolegs. There may be certain fleshy protuberances, and nearly all sphecid larvae have a series of

pleural lobes along the sides of the body just below the line of spiracles. In most species the dorsum of each segment is crossed by one or more transverse furrows, dividing it into two or more *annulets*; usually there are only two, called the *anterior* and *posterior annulets*. There may be small lobes above and below the anus, called *supra-anal* and *subanal lobes*, respectively. The integument may be smooth, granulose, or spinulose; body setae may be entirely absent, or there may be small setae present on certain parts of the body.

There are ten pairs of *spiracles*, two on the thorax and one on each of the first eight abdominal segments. The spiracular *peritremes* are generally light brown in color; beneath the peritreme the outer chamber or *atrium* of the spiracle may bear various arrangements of ridges and spines. The atrium is separated by a heavy circle of spines from the *subatrium*, which in turn leads into the trachea.

Measurements of total body length are made with the specimen extended in a straight line; the head capsule is included in such measurements. Measurements of maximum body diameter are made by placing the specimen on its dorsum and measuring the greatest transverse width.

Head.—The head is sclerotized, but except for certain parts is colored about like the body; punctures and setae are usually present on the head capsule. In anterior view, the head is subcircular. Head width is measured at its maximum point; height is measured from the top of the vertex (in full front view) to the apex of the clypeus; the labrum is not included in such measurements, since it is somewhat extensile.

The cleavage line is usually evident on the top of the cranium as a short, median line, here termed the *coronal suture*. In many forms there is a pair of oblique, often lightly pigmented lines, one on each side of the front of the head capsule, the *parietal bands* (ocular lines of Short). The *antennae* arise from more or less circular, unsclerotized *antennal orbits*; they may be one-segmented, with three minute sensilla at the apex, or there may be no projecting papilla, the sensilla lying separately in the membrane of the orbit. The *epistomal suture* separating the front from the clypeus is usually apparent; the *labroclypeal suture* is a prominent

fold overhanging the base of the labrum. The *anterior tentorial arms* are evident as thick, pigmented lines on each side of the clypeus, extending obliquely toward the antennal orbits; these are continuous with thickenings of the integument above the bases of the mandibles, the *pleurostomal thickenings,* which in turn are continuous with the *hypostomal thickenings,* which extend backward from the posterior articulation of the mandibles to the *posterior tentorial arms.*

Mouthparts.—The *labrum* is variously shaped and may bear a considerable variety of setae and sensilla which often provide taxonomic characters; it is capable of extension and retraction in relation to the clypeus. The under surface of the labrum, or *epipharynx,* is usually spinulose; on each side of the median line is an area devoid of spinules and bearing several small pores, presumably sensory organs; these areas are here termed the *epipharyngeal sensory areas.* The *mandibles* are heavily sclerotized and usually darkly pigmented, at least apically; their apices are divided into a variable number of teeth. The fleshy area at the base of the mandibles is the *mandibular corium*; through the membrane may be seen the adductor and abductor apodemes of the mandibles. The dorsal articulation of the mandibles is called the *epicondyle,* the ventral the *hypocondyle.* The *maxillae* are fleshy, the greater part consisting of the *stipes,* which bears at its apex two slightly sclerotized, lightly pigmented papillae; the lateral papilla is the *maxillary palpus,* and the mesal papilla the *galea*; the roughened, often spinulose area mesad of the galea is spoken of as the *lacinial area.* The *labium* consists of a large *postmentum* and a smaller *prementum*; the latter bears the slightly sclerotized *labial palpi* and the opening or openings of the salivary (silk) glands, here called the *spinneret.* The *hypopharynx* is a fleshy projection in the center of the mouthparts, often covered with spinules or papillae.

Subfamily Sphecinae

The larvae of the Sphecinae may be readily separated from all other Sphecidae by the following combination of characters: integument of the body minutely spinulose or granulose, but without setae except occasionally for some extremely minute ones on the thoracic dorsum; head setae very short or absent; parietal bands

well developed, often conspicuous; antennal papilla absent, the (usually) three antennal sensilla arising directly from the membrane of the orbit; labrum biconvex, its apical margin slightly to deeply emarginate, its surface punctate, sometimes setose; apical margin of labrum narrowly set off, frequently somewhat darkened and striate, and often bearing sensilla which either are set into the margin or protrude from it; mandibles stout, terminating in four teeth, the most basal of which may be variously modified; galeae as long as, usually longer than, the maxillary palpi; spinneret consisting of a transverse slit with prominent raised lips.

The four tribes of Sphecinae are clearly definable on larval characters, as indicated in the following table. Within each tribe, the genera are less clearly definable. The generic characters presented below are tentative, pending the description of the larvae of additional species. In the following table we have indicated the species of each genus which we have studied; the species known to us only from published descriptions are enclosed in brackets. We have seen larvae of one or more species of each genus of Sphecinae occurring in North America with the exception of *Chlorion* (*s.s.*), with the single species *aerarium* Patton. This group therefore does not appear in our table.

Table of Tribal and Generic Characters

A. Apical margin of labrum frequently striate or with small sensilla which do not protrude from the margin, the surface of the labrum at most with very minute setae (figs. 5, 43); head about .2 (not over .28) as wide as the maximum body width; thorax without dorsal callosites except in *Isodontia*, where they are weakly developed.

B. Mandibles stout and heavy, less than twice as long as their maximum breadth, and without spinules on their upper surface (figs. 1, 22); body spiracles all in one line (figs. 3, 25) .....SPHECINI [2]

C. Head higher than broad (fig. 15); galeae and maxillary palpi subequal in length (fig. 17); integument of body with minute spinules arising from plate-like bases (fig. 18) *Prionopyx* (*atratus, thomae*)

[2] Traditionally the tribe Sphecini (or Chlorionini) has been considered to contain a single genus, *Sphex* (or *Chlorion*), with several subgenera. It is the feeling of the writers that the characters separating these subgenera, both in the adult and in the larva, are sufficient to warrant elevating these groups to generic rank, which we have done here. The ethological differences between these groups (at least, certainly, in the case of *Isodontia* and *Prionopyx*) are even more striking.

CC. Head as broad or broader than high (figs. 1, 23); galeae slightly to considerably longer than the maxillary palpi (figs. 6, 14, 28).

D. Galeae somewhat horn-shaped, exceeding the maxillary palpi as 3:2 (figs. 28, 30, 32); body more or less cylindrical, the thorax with paired subdorsal welt-like elevations (fig. 25); spinules of the lacinial area more or less recurved (figs. 28, 30, 32)
Isodontia (*harrisi, azteca, auripes*)

DD. Galeae tapering from base to apex more evenly, exceeding the maxillary palpi about as 5:4 (figs. 6, 11, 14); body with the anterior third quite slender, the thorax without welt-like elevations (fig. 3).

E. Antennal orbits eccentric (fig. 13); emargination of labrum hardly greater than that of the clypeus (fig. 12), the labrum with punctures over much of its surface
Palmodes (*daggyi*)

EE. Antennal orbits subcircular (figs. 4, 10); emargination of labrum distinctly greater than that of the clypeus, the punctures of the labrum largely restricted to the anterior half (figs. 5, 9)
Sphex (*ichneumoneus, pensylvanicus, umbrosus*)

BB. Mandibles more slender, more than twice as long as their greatest thickness, terminating in four slender teeth, the most basal of which may be variously modified, the upper surface of the mandibles with scattered minute spinules (figs. 34, 44-46, 49, 59, 62); thoracic spiracles offset below the line of abdominal spiracles (figs. 36, 42) .....AMMOPHILINI

C. Basal tooth of mandibles not at all protruding as a distinct tooth, but represented by a row of 7 or 8 minute denticles (fig. 34); anterior margin of clypeus conspicuously emarginate (fig. 37) .....*Podalonia* (*clypeata*, [*tydei*])

CC. Basal tooth of mandibles evident and protruding, although usually subdivided (figs. 44-46, 49, 59, 62); anterior margin of clypeus emarginate (figs. 43, 47, 57, 60)
Ammophila (*procera, urnaria, harti, juncea*, [*campestris*])

AA. Apical margin of labrum with several distinct, protruding, barrel-shaped sensilla, the surface of the labrum with fairly long setae (figs. 53, 63, 65, 73); head at least .3 as wide as the maximum body width; thorax with two or three pairs of prominent subdorsal callosities (figs. 52, 71).

B. Apical margin of labrum with some rather long setae protruding from it (fig. 73); setae on the lower sides of the head capsule minute and few in number (fig. 69); thoracic callosities somewhat sclerotized, weakly pigmented, and bearing small setae (fig. 71) PODIINI, *Podium* (*carolina*)

BB. Apical margin of labrum without long setae protruding from it (figs. 53, 63, 65); setae on lower sides of head capsule abundant, fairly long (figs. 50, 68); thoracic callosities relatively unsclerotized, unpigmented (fig. 52) .....SCELIPHRONINI

C. Top and sides of the head capsule only rather weakly roughened (fig. 50); epipharyngeal sensory pores well scattered, some being close to the anterior margin (figs. 53, 63) *Sceliphron* (*caementarium, assimile,* [*spirifex*])

CC. Top and sides of the head capsule roughened by many small convexities (fig. 68); epipharyngeal sensory pores well removed from the anterior margin (fig. 65) *Chalybion* (*californicum*)

Sphex ichneumoneus (Linnaeus) (Plate I, figs. 1-8)

Body.—Length 33 mm.; maximum width (abdominal segment 6) about 8 mm. Pale yellowish-white, the spiracles light brown with a darker rim; body without evident setae, the integument granular (fig. 2). Body fusiform, the thorax strongly tapering toward the small head capsule (fig. 3). Each segment divided dorsally into two annulets of about equal size; each abdominal segment with a prominent, rounded pleural lobe on each side; between the lobes the intersegmental lines are obliterated. Anus transverse, its lips not protuberant. Thoracic spiracles very slightly smaller than abdominal spiracles. Spiracular atria (fig. 8) with a series of rings of spines.

Head.—Width 1.55 mm.; height 1.52 mm. (fig. 1). Straw-colored; top and sides of cranium faintly blotched with brown; mandibles dark brown, their tips nearly black; parietal bands brown; a vertical brownish blotch at the antennal orbits and two pairs of blotches on the front of the head, one pair mesad of the orbits and one pair on the clypeus; labroclypeal suture and apical margin of labrum brownish; pleurostomal and hypostomal thickenings dark brown; narrow ventro-mesal margin of the maxilla brown; sides of prementum with large, crescentic, dark brown areas, the median portion unpigmented; palpi and galeae brownish. Coronal suture distinct, reaching approximately to the upper level of the parietal bands, the latter strong, .4 mm. long. Antennal orbits (fig. 4) circular, small, 63 μ in diameter, each containing three minute sensory cones. Antennal orbits situated in weak vertical depressions which extend nearly to the parietal bands. Anterior tentorial arms extending about half way from the mandibular coria to the antennae. Epistomal suture weak. Front with scattered small punctures, more numerous below; clypeus with many punctures.

Mouthparts.—Labrum broad, its anterior margin with a deep, broadly V-shaped emargination (fig. 5). Width of labrum .7 mm.; maximum

height .27 mm.; median height .19 mm.; labrum thus 2.6 times as wide as its maximum height, 3.7 times as wide as its median height. Anterior margin of labrum with a narrow, darky pigmented band, widened medially, somewhat striate; upper surface of labrum with a few small punctures which are crowded toward the anterior margin. Epipharynx spinulose, the spinules longest antero-medially, and here directed mesad; sensory areas pigmented, each with about 5 pores. Mandibles stout, their apices with four strong teeth in nearly the same plane; length of mandibles .68 mm., width at the base .35 mm. Maxillae with the palpi 85 μ in length, 55 μ wide at the base, terminating in five small sensory cones; galeae 100 μ long, 60 μ wide at the base, terminating in two sensilla; lacinial area coarsely spinulose, the lateral portion of the stipes with a few small setae (fig. 6). Labial palpi about 70 μ in length and 52 μ wide at the base, terminating in several sensory cones; spinneret a transverse slit about .6 mm. long, the lips protuberant to about the same height as the labial palpus (fig. 7).

Material.—Five specimens collected at Ithaca, N. Y., by Dr. Samuel Ristich.

Sphex pensylvanicus Linnaeus (Plate II, figs. 9-11)

Body.—Length 28 mm.; maximum width 7 mm. In the two available specimens, which were removed from cocoons, the pleural lobes are smaller and much more convex than in *ichneumoneus*, which they otherwise resemble very closely.

Head.—Width 1.8 mm.; height about the same. Colored as in *ichneumoneus*, except the top and sides of the cranium with slightly more prominent blotches of brown and the brownish areas on the prementum much more widely separated medially. Parietal bands .6 mm. long. Antennal orbits nearly circular, 95 μ in diameter (fig. 10). Punctures distributed as in *ichneumoneus*.

Mouthparts.—In most details very much like *ichneumoneus*. Labrum (fig. 9) .87 mm. wide, maximum height .3 mm., median height .27 mm; labrum thus 2.9 times as wide as its maximum height, 3.2 times as wide as its median height. Apical emargination of labrum somewhat broader than in *ichneumoneus*; epipharyngeal sensory area larger than in that species, tending to crowd the spinules toward the anterior margin; backward-directed spinules on median portion of epipharynx larger and more numerous than in *ichneumoneus*. Mandibles .85 mm. long, .44 mm. wide at the base. Maxillary palpi 110 μ long, galeae 125 μ long (fig. 11); labial palpi 95 μ long.

Material.—Two specimens from Woodstock, Maryland, removed from cocoons on May 5, 1922 (E. G. Reinhard) [U. S. Nat. Mus.].

Sphex umbrosus Christ

Head.—Width 1.6 mm.; height about 1.4 mm. (the head of the available specimen is slightly crushed; hence these figures are approximate). Parietal

bands strong, about .6 mm. long. Antennal orbits nearly circular, 70 μ in diameter. Apical margin of clypeus not at all emarginate.

Mouthparts.—Labrum shaped almost exactly as in *ichneumoneus*, with the same type of apical emargination; width of labrum .76 mm.; maximum height .27 mm.; median height .20 mm. Details of the epipharynx not clearly visible in the available specimen. Mandibles shaped as in *ichneumoneus*; galea slightly exceeding the maxillary palpi.

Material.—Described from a head capsule mounted in balsam by F. X. Williams, and loaned by the Experiment Station of the Hawaiian Sugar Planters' Association. Specimen collected at Los Baños, Philippines, in 1916. Although many of the details are not visible in this preparation, the grosser aspects agree closely with the North American species of *Sphex*.

Palmodes daggyi (Murray) (Plate II, figs. 12-14)

Body.—Length 30 mm.; maximum width 6.5 mm. Similar in form to *Sphex ichneumoneus*; thorax and first abdominal segment more slender than the rest of the body and more or less devoid of fat body and urate crystals; pleural lobes and dorsal annulets barely evident in the single available specimen. Integument granular, as in *Sphex ichneumoneus*, the spiracles not noticeably different from that species.

Head.—Width 1.56 mm.; height virtually the same. Light brown, with some indistinct blotching on the top and sides; coronal suture long, dark brown; parietal bands lightly pigmented; anterior tentorial arms and pleurostomal and hypostomal thickenings dark brown; mandibles dark brown to black; front with two pairs of faint blotches. Front with scattered but distinct punctures over much of its surface; clypeus with somewhat closer punctures; minute setae arise from some of the punctures on both front and clypeus. Antennal orbits (fig. 13) slightly produced mesad, about 70 μ in maximum diameter.

Mouthparts.—Clypeus arcuately emarginate apically, the labrum with an apical emargination which is barely deeper (fig. 12). Labrum .77 mm. wide, .26 mm. high, .25 mm. high on the median line; labrum thus about 3 times as wide as high. Upper surface of labrum almost wholly covered with punctures; apical margin about as in *Sphex*. Epipharynx spinulose except in the vicinity of the sensory areas, which are dark and contain 6 pores in a group; the median spinules are fairly long and directed inward. Mandibles shaped as in *Sphex*, measuring .7 mm. long and .4 mm. wide at the base. Maxillae with the palpi 105 μ long; galeae 120 μ long; lacinial area roughened, not noticeably spinulose (fig. 14). Labial palpi 85 μ long.

Material.—One specimen reared by K. V. Krombein from an egg collected June 24, 1954, at Nags Head, N. C.

Prionopyx atratus (Lepeletier) (Plate II, figs. 15-20)

Body.—Length 23 mm.; maximum width 5 mm. Similar to the preceding four species; anterior part of body slender and neck-like; pleural lobes rather weakly developed. Integument minutely spinulose, the spinules arising from plate-like bases (fig. 18).

Head.—Width 1.15 mm.; height 1.25; head thus noticeably higher than broad (fig. 15). Pale straw-colored, without blotches or other pigmented areas; parietal bands and margin of labrum scarcely pigmented; mandibles and pleurostomal and hypostomal thickenings brown. Coronal suture reaching to the upper level of the parietal bands, the latter .4 mm. long. Antennal orbits slightly eccentric, about 70 μ in maximum diameter, each with three small sensory cones (fig. 16). Epistomal suture fairly well defined. Front and clypeus with a few small, scattered punctures.

Mouthparts.—Labrum (fig. 19) .67 mm. wide, .22 mm. high, thus about three times as wide as high; emargination of labrum slightly sharper but scarcely deeper than that of the clypeus. Surface of labrum punctate, more densely so toward the anterior margin, which is somewhat striate. Epipharynx spinulose except in the area of the sensory pores, of which there are four on each side, placed well back from the margin; spinules on the sides directed forward, those in the median area directed backward. Mandibles about as in *Sphex* and *Palmodes*, the mesal margin somewhat more hollowed out, the apex with three large teeth and a smaller fourth tooth basad of these; length of mandible .55 mm., maximum width .31 mm. Maxillae with the palpi 86 μ in length and about 50 μ wide at the base; galeae almost exactly the same size; lacinial area roughly spinulose, many of the spines on the mesal margin hooked inward (fig. 17). Labial palpi 70 μ long and 47 μ wide at the base; spinneret about as in *Sphex*, about .55 mm. long (fig. 20).

Material.—Two specimens collected by the writers in Pottawatomie Co., Kansas, Aug. 3-6, 1952.

Prionopyx thomae (Fabricius) (Plate III, figs. 21, 22)

Body.—Length 18 mm.; maximum width 5 mm. (the single available specimen is probably not quite full-grown). Form as in *atratus*, the pleural lobes rather pronounced, the abdominal tergites rather distinctly divided into two subequal annulets.

Head.—Width .8 mm.; height .9 mm. Antennal orbits slightly eccentric, 55 μ in maximum diameter. Other features as in *atratus*.

Mouthparts.—Labrum (fig. 21) much as in *atratus*, but the apical margin with several circular pores on each side of the median line; epipharyngeal sensory area consisting of about seven pores on each side, which are less far removed from the margin than in *atratus*. Mandibles (fig. 22) shaped as in *atratus*, .4 mm. long and .22 mm. wide at the base. Details of the maxillae and labium not differing noticeably from *atratus*, the spinules on the lacinial area recurved as in that species.

Material.—A single specimen collected by H. E. Evans in Kearny Co., Kansas, Aug. 20, 1952.

Isodontia harrisi (Fernald) (Plate III, figs. 23-28)

Body.—Length 18 mm.; maximum width 5 mm. Body (fig. 25) but slightly more tapering anteriorly than posteriorly, the ventral surface somewhat flattened, the dorsal surface convex; pleural lobes very prominent, the intersegmental lines not obliterated between them. Tergites each with a prominent transverse furrow which marks off two subequal annulets; anterior portion of each posterior annulet with a transverse, welt-like elevation, interrupted medially. Mesothorax with a pair of fairly prominent welt-like elevations, one on each side of the median line. Integument weakly spinulose. Spiracular atria (fig. 27) with a network of hexagonal ridges; subatria elongate, slender.

Head.—Width 1.15 mm.; height 1.07 mm. (fig. 23). Pale straw-colored, without blotching, the coronal suture and parietal bands unpigmented; pleurostomal and hypostomal thickenings brown; mandibles brown, their apices ferruginous; prementum with a brown area on each side, widely separated medially. Coronal suture short; parietal bands unusually long, about .5 mm. in length. Antennal orbits (fig. 24) ovoid, 80 μ in greatest diameter. Epistomal suture weak. Front with a few scattered punctures.

Mouthparts.—Labrum (fig. 26) .5 mm. wide, .21 mm. high, .16 mm. high on the median line; labrum thus 2.4 times as wide as high, 3.1 times as wide as its median height. Surface of labrum with conspicuous punctures; apical margin thickened, with several circular pores on each side of the rather deep median emargination. Epipharynx spinulose, much as in *Prionoryx*, but the spinules mostly rather small; sensory areas unpigmented, the pores numbering seven on each side. Mandibles .5 mm. long, .28 mm. wide at the base; apex with four strong teeth in a row; mesal margin somewhat hollowed out. Maxillae with the palpi 60 μ in length, 40 μ in width at the base; galeae 90 μ in length, 50 μ in width at the base, tapering strongly from the base; lacinial area with dense spinules, some of which are recurved, as in *Prionoryx* (fig. 28). Labial palpi 65 μ long; lips of the spinneret slightly protuberant.

Material.—Three specimens labeled "Alabama ? in pitcher plant; Benedict coll."; one specimen labeled "from nest in *S*[*arracenia*] *sledgei*, Biloxi, Miss." [all U. S. Nat. Mus.].

Isodontia azteca (Saussure) (Plate IV, figs. 29, 30)

Body.—Length 20 mm.; maximum width 6 mm. Very similar to *harrisi*, the pleural lobes slightly less prominent.

Head.—Width 1.4 mm.; height 1.2 mm. Antennal orbits ovoid, 80 μ in maximum diameter.

Mouthparts.—Labrum (fig. 29) less deeply emarginate than in *harrisi*, .6 mm. wide, .25 mm. high, .22 high on the median line; labrum thus 2.4 times as wide as high, 2.7 times as wide as its median height. Epipharynx much as in *harrisi*, but the lateral spinules somewhat more sparse. Galeae considerably longer than the maxillary palpi, as in *harrisi*, the galeae somewhat horn-shaped (fig. 30).

Material.—A single specimen from Vienna, Va., collected by J. C. Bridwell on Dec. 6, 1941 [U. S. Nat. Mus.].

Isodontia auripes (Fernald) (Plate IV, figs. 31, 32)

Body.—Length 19 mm.; maximum width 6 mm. Features as in *harrisi*.

Head.—Width 1.35 mm.; height 1.22 mm. Antennal orbits shaped as in the preceding two species, their maximum diameter 80 μ. Parietal bands long, about .5 mm. in length. Other features as in *harrisi*.

Mouthparts.—Labrum (fig. 31) rather deeply emarginate, its maximum width .6 mm., maximum height .23 mm., median height .2 mm.; emargination with a rather extensive pigmented area at its base; spinules of the epipharynx rather sparse laterally, as in *azteca*. Maxillary palpi 70 μ in length, the galeae distinctly horn-shaped, 100 μ in length.

Material.—A single specimen collected by K. V. Krombein at Kill Devil Hills, Dare Co., N. C., 25 July 1955.

Podalonia clypeata Murray (Plate IV, figs. 33-38)

Body.—Length 20 mm.; maximum width 5 mm. Fusiform, strongly tapered anteriorly to the small head capsule (fig. 36); ventral surface somewhat more flattened than the dorsal; each abdominal segment with a fairly strong pleural lobe, below which is a feebly defined longitudinal impression; each tergite divided by a transverse impression into two annulets of about equal size. All spiracles about the same size, the thoracic spiracles offset slightly below the line of abdominal spiracles. Integument minutely spinulose.

Head.—Width .92 mm.; height .82 mm. (fig. 33). Pale, the coronal suture, parietal bands, and rim of the antennal orbits light brown; pleurostomal and hypostomal thickenings brown; mandibles dark brown apically; galeae, palpi, and inner basal portion of the prementum brownish. Parietal bands about .32 mm. long, rather wide. Antennal orbits (fig. 35) elliptical, about 60 μ in maximum diameter. Epistomal suture well-defined; anterior margin of clypeus emarginate. Front and clypeus with widely scattered punctures.

Mouthparts.—Labrum (fig. 37) .38 mm. wide, .14 mm. high, .16 mm. high on the median line; median height greater than the height on the sides because of the fact that the clypeus is more deeply emarginate than the labrum. Surface of labrum punctate, the punctures more crowded toward the anterior margin. Epipharynx spinulose, the median spinules much smaller than the laterals; sensory area consisting of 3 to 5 pores on each

side. Mandibles (fig. 34) .38 mm. long and .17 mm. wide at the base; apex with three prominent teeth; basad of the inner tooth is a series of about 7 minute, sharp teeth; upper surface of mandibles with scattered minute spinules. Maxillae (fig. 38) with the palpi 55 μ long and about 37 μ wide at the base; galeae about 70 μ long and 40 μ wide at the base; lacinial area densely spinulose. Labial palpi 60 μ long, terminating in several rather prominent sensilla; spinneret about .35 mm. in length, the lips protruding to about the length of the palpi.

Material.—A single specimen reared from an egg taken from a nest in Stafford Co., Kansas, on July 20, 1954 (H. E. Evans).

Podalonia tydei (LeGuillou)

Soika (1934, Ann. Soc. Ent. France, 103: 343) has described the larva of this European species. He describes the head capsule as being slightly wider than high; the labrum is but weakly emarginate apically, as in *clypeata*; the basal tooth of the mandibles is not at all developed, but is represented by a series of 8 minute denticles, almost exactly as in *clypeata*. There appear to be minor differences in the spinules and pores on the epipharynx, but otherwise Soika's description and figures of *tydei* would fit *clypeata* almost equally well.

Ammophila procera Dahlbom (Plate V, figs. 39-46)

Body.—Length 23 mm.; maximum width about 6 mm. (fig. 42). Fusiform, strongly tapered anteriorly, the prothorax especially long and neck-like. Pleural lobes moderately developed, partially obliterating the intersegmental lines; dorsal annulets prominent on the thorax, less so on the abdomen. Thoracic spiracles offset slightly below the line of the abdominal spiracles; second thoracic spiracles very slightly smaller than the others. Integument spinulose (fig. 40).

Head.—Width 1.13 mm.; height .94 mm. Head pigmented about as in *Podalonia clypeata*; head with shallow depressions just above each antennal orbit, on each side of the median line of the front, and on each side of the clypeus. Antennal orbits obliquely elliptical (fig. 41), about 70 μ in maximum diameter. Parietal bands .33 mm. long. Front with a few punctures above and below the antennal orbits, from some of which arise minute setae; clypeus with scattered punctures. Epistomal suture weakly developed; anterior margin of clypeus weakly emarginate.

Mouthparts.—Labrum (fig. 43) .49 mm. wide, .19 mm. high, .17 mm. high on the median line; labrum thus 2.6 times as wide as high, 2.8 times as wide as its median height. Upper surface of labrum with scattered punctures, from some of which arise minute setae; anterior margin with a median emargination. Epipharynx spinulose; sensory area consisting of 6 or 7

pores on each side. Mandibles (figs. 44-46) .5 mm. long and .24 mm. wide at the base; apex with three sharp teeth, the basal one deflected inward; fourth and innermost tooth rather blunt and usually more or less subdivided, in one specimen before us merely truncate (fig. 44), in another divided into two (fig. 45), and in another divided into three sharp denticles (fig. 46); upper surface of mandibles with scattered minute spinules. Maxillae with the palpi about 70 μ long, the galeae horn-shaped, about 90 μ long. Labial palpus 55 μ long.

Material.—Four specimens reared by the authors from nests found in Pottawatomie Co., Kansas, June 24-July 11, 1952-53.

Ammophila urnaria Dahlbom (Plate V, figs. 47-49)

Body.—Length 16 mm.; maximum width 5.2 mm. Much as described for *procera*; pleural lobes and dorsal annulets fairly prominent.

Head.—Width .84 mm.; height .68 mm. Antennal orbits (fig. 48) ovoid, 50 μ in maximum diameter. Front with paired depressions as in *procera*, and with a very few minute punctures above and below the orbits.

Mouthparts.—Labrum (fig. 47) weakly emarginate apically, less so than in *procera*; width of labrum .4 mm., height .12 mm. Mandibles (fig. 49) .4 mm. long and .18 mm. wide at the base; outer three teeth as in *procera*, the innermost tooth divided into about 7 minute denticles. Maxillae with the palpi 60 μ long, the galeae 90 μ long, somewhat horn-shaped. Labial palpi 60 μ long; lips of the spinneret prominent.

Material.—Described from two specimens collected at Ithaca, N. Y., by C. S. Lin and C. M. Yoshimoto, on July 1 and on Sept. 8, 1954.

Ammophila harti (Fernald) (Plate VII, figs. 57-59)

Body.—Length 18 mm.; maximum width 5 mm. Form as in *procera*.

Head.—Width .83 mm.; height .76 mm. Antennal orbits less eccentric than in the preceding two species, nearly circular (fig. 58), measuring about 55 X 65 μ. Front and clypeus with paired depressions as in *procera*, and with a few punctures as in that species.

Mouthparts.—Labrum (fig. 57) rather deeply emarginate apically; width .37 mm.; height .12 mm.; median height .09 mm. Mandibles (fig. 59) .38 mm. long, .18 mm. wide at the base; basal tooth of mandibles fairly strong, weakly subdivided at the tip. Maxillae with the palpi 52 μ long, the galeae 75 μ long; labial palpi 55 μ long.

Material.—Three specimens reared by the authors from nests found in Reno, Stafford, and Grant Counties, Kansas, in July and August, 1952-53.

Ammophila juncea Cresson (Plate VII, figs. 60-62)

Body.—Length 19 mm.; maximum width 5 mm. Similar to that of the preceding three species; much narrowed anterior to abdominal segment two; thoracic spiracles offset below the line of abdominal spiracles and very slightly smaller than these.

Head.—Width .95 mm.; height .7 mm., the head thus considerably broader than high. Antennal orbits (fig. 61) ovoid, measuring about 70 X 85 μ.

Mouthparts.—Labrum (fig. 60) .4 mm. wide, .14 mm. high, .12 mm. high on the median line; apical emargination about as in *procera*, deeper than in *urnaria*. Epipharynx with fewer spinules than in the other species, especially anterior to the sensory pores. Mandibles (fig. 62) .4 mm. long and .18 mm. wide at the base; basal tooth short and somewhat irregularly divided into four small denticles. Maxillary and labial palpi both about 60 μ long and 40 μ wide at the base; galeae horn-shaped, 100 μ long and 55 μ wide at the base.

Material.—Three specimens collected by the senior author in Pottawatomie Co., Kansas, June 15-Aug. 15, 1952-53.

Ammophila campestris Latreille

The larva of this European species has been described by Grandi (1926, Boll. Lab. Zool. Portici, 19: 276-279). The species agrees closely with the American species. The antennal orbits are circular; the anterior margin of the labrum is rather deeply emarginate; the basal tooth of the mandible is short but acutely pointed and not subdivided; the galeae are horn-shaped and considerably longer than the maxillary palpi.

Sceliphron caementarium (Drury) (Plate VI, figs. 50-56)

Body.—Length 20 mm.; maximum width (abdominal segment 5) 5 mm. Stout, cylindrical, not notably attenuated anteriorly (fig. 52). Pleural lobes fairly strong, the intersegmental lines incompletely obliterated between them; tergites somewhat transversely wrinkled, each with a strong transverse impression dividing it into two subequal annulets. Thoracic spiracles slightly larger than abdominal spiracles, but in line with them. Thorax with a pair of prominent oval callosities, one on each side of the mid-dorsal line, just anterior to the first pair of spiracles; also with a pair of smaller, more lateral callosities anterior to these; these callosities are unpigmented and barely, if at all, sclerotized. Integument minutely spinulose. Spiracular atria (fig. 56) with the walls divided into irregular hexagons by a network of ridges; subatria short and subglobose.

Head.—Width 1.7 mm.; height 1.45 mm. (fig. 50). Pale yellowish-white, like the body; coronal suture and parietal bands lightly pigmented; labroclypeal suture, anterior tentorial arms, and pleurostomal thickenings

brown; mandibles brown, their apices black; a light brown spot just antero-mesad of each antennal orbit, a pair of light brown spots in the middle of the front, and a pair of weak blotches on the clypeus; ventro-mesal margin of maxilla and sides of the prementum brownish. Tops and sides of the cranium with numerous small convexities. Parietal bands about .4 mm. long. Antennal orbits transversely ovoid, 80 μ in maximum diameter, with a small circular central area 35 μ in diameter bearing three sensory cones (fig. 51). Front and clypeus with scattered punctures, from some of which arise small setae; above the bases of the mandibles these are more crowded and some of the setae are fairly long.

Mouthparts.—Labrum (fig. 53) shallowly emarginate apically, each lateral lobe strongly convex on the anterior surface; width .62 mm.; height .27 mm.; median height .25 mm.; labrum thus about 2.5 times as wide as high. Upper surface of labrum with numerous rather strong setae, with additional punctures interspersed; anterior margin with five well-defined, barrel-shaped sensilla on each side of the median line. Epipharynx with numerous small forward-directed spinules, mostly confined to the sides; sensory area consisting of about 12 irregularly distributed pores on each side, the most anterior 3 of which are large and dark-rimmed, and lie rather close to the margin of the epipharynx. Mandibles stout; length .6 mm.; maximum width .38 mm.; mesal margin of mandibles somewhat hollowed out, the apex with four blunt teeth. Maxillary palpi 100 μ in length; galeae 110 μ in length, horn-shaped, strongly tapering from the base; lacinial area roughened, the spinules small (fig. 54). Labial palpus 60 μ in length; spinneret about .45 mm. long, the lips raised to about the height of the palpus; surface of the prementum, on both sides of the spinneret, strongly papillose (fig. 55).

Material.—Six specimens taken from a mud nest at Selkirk, Oswego Co., N. Y., Aug. 20, 1955 (H. E. Evans); ten specimens taken from a mud nest at Urbana, Ill., Nov. 18, 1941 (H. H. Ross) [Ill. Nat. Hist. Survey].

Sceliphron assimile (Dahlbom) (Plate VII, figs. 63, 64)

Body.—Length 18 mm.; maximum width 5 mm. Form virtually the same as in *caementarium*, including two pairs of similar convexities on the thorax.

Head.—Width 1.7 mm.; height 1.4 mm.; parietal bands .5 mm. long; antennal orbits shaped as in *caementarium* but larger, 110 μ in maximum diameter. Punctures and setae as in *caementarium*, all of the setae quite short.

Mouthparts.—Labrum (fig. 63) slightly more deeply emarginate than in *caementarium*; width .6 mm.; height .23 mm.; median height .21 mm. Details of surface and anterior margin not differing noticeably from *caementarium*; epipharynx differing from that species in the arrangement of the sensory pores and in having a slightly larger number of spinules medially.

Mandibles as in *caementarium*. Maxillae (fig. 64) with the palpi 85 μ in length; galeae horn-shaped, 120 μ in length. Labial palpi about 60 μ in length.

Material.—Twelve specimens from Santa Clara, Cuba (Richard Dow) [U. S. Nat. Mus.].

Sceliphron spirifex (Linnaeus)

The larva of this European species has been described by Grandi (1929, Boll. Lab. Ent. Bologna, 2: 264; 1937, Boll. Lab. Ent. Bologna, 9: 302). The resemblance to *caementarium* is striking, extending even to the arrangement of pigment spots on the head. In this species there are apparently only four sensilla on each side of the median line of the apical margin of the labrum, with a small fifth one at the outer angles; the galea seems to be less strongly tapered from the base; and the epipharyngeal sensory spots are slightly differently arranged.

Chalybion californicum (Saussure) [3]

(Plate VII, figs. 65, 66; plate VIII, figs. 67, 68)

Body.—Length 22 mm.; maximum width 5.2 mm. In every respect similar to *Sceliphron*, including the callosities on the thorax. Integument spinulose, but the spinules apparent only under high magnification.

Head.—Width 1.75 mm.; height 1.52 mm. (fig. 68). Top and sides of the head capsule with conspicuous small convexities, much more noticeable than in *Sceliphron*. Head with scattered small punctures, from many of which arise small setae; these are especially abundant on the lower sides of the head. Coloration of head as in *Sceliphron caementarium*. Antennal orbits transversely ovoid, their maximum diameter 95 μ.

Mouthparts.—Labrum (fig. 65) with a shallow apical emargination; width .66 mm.; height .26 mm. Features of the labrum and epipharynx much as in *Sceliphron*; there appears to be much interspecific variation in the exact number (4-7) and position of the barrel-shaped sensilla on each side of the median line of the apical margin; the sensory pores are scattered over the median area of the epipharynx, with the anterior two well removed from the margin, larger and more pigmented than the others. Mandibles .65 mm. long and .40 mm. wide at the base, the apex with four stout teeth. Maxillary palpi 100 μ in length; galeae very strongly tapered from the base, 120 μ

[3] The larvae described here were taken from a *Sceliphron* nest which showed evidence of having been reutilized by another wasp. The cocoons in the nest resembled *Sceliphron* in general, but differed in having a whitish outer layer of silk not present in *Sceliphron*. The larvae also resemble *Sceliphron* closely, yet exhibit enough differences to lead one to conclude they may represent larvae of *Chalybion*. As yet no adult wasps have been reared from this material, so the identification cannot be confirmed.

long (fig. 66). Labial palpi short and stout, about 65 X 50 μ, terminating in two very sharply pointed sensilla (fig. 67).

Material.—Seven specimens taken from a mud nest at Selkirk, N. Y., Aug. 25, 1955 (H. E. Evans).

Podium carolina Rohwer[4] (Plate VIII, figs. 69-73)

Body.—Length 15.5 mm.; maximum width 4 mm. (fig. 71). Cylindrical, slightly more tapered anteriorly than posteriorly; dorsum scarcely more convex than venter. Pleural lobes rather feebly convex, the intersegmental lines, however, obliterated between them. Each abdominal segment weakly divided dorsally into two annulets; thoracic segments somewhat irregularly divided. Thorax with a pair of subdorsal, transversely oval callosities located just above and anterior to the first pair of spiracles; these are lightly sclerotized and weakly pigmented, and bear a few small setae. Just anterior to these are two additional pairs of smaller and more lateral callosities. Anus transverse; apical tergite, just above the anus, with a rounded convexity which appears to be lightly sclerotized. Spiracles small, the anterior pair slightly larger than the others; sculpture of spiracular atria very similar to that of *Sceliphron*. Integument conspicuously spinulose.

Head.—Width 1.2 mm.; height 1.05 mm. (fig. 69). Color pale straw, with faint blotching on the top and sides of the cranium; coronal suture and parietal bands unpigmented; front with a pair of small transverse impressions in the middle which are brownish in color; a second pair of brown spots occupies depressions extending from the antennal orbits to the epicondyles; anterior tentorial arms and pleurostomal and hypostomal thickenings brown; mandibles light brown, darker apically; cardo and margins of stipes brown; prementum with a basal brown band which is broadly interrupted on the mid-ventral line. Antennal orbits transversely ovoid, 70 μ in maximum diameter. Punctures of head very sparse and inconspicuous, those on the lower sides of the head bearing a few minute setae; clypeus with scattered punctures, a few of which bear setae.

Mouthparts.—Labrum (fig. 73) .4 mm. wide, .16 mm. high, .14 mm. high on the median line; upper surface with punctures and some rather long setae toward the anterior margin, some of the setae situated close to the margin and projecting conspicuously from it; apical margin with 6 well-defined sensilla on each side of the median line, and 2 or 3 ill-defined ones laterad of these. Epipharynx weakly spinulose, the median spines small and directed basad or mesad; sensory pores about 12 on each side, well scattered, the anterior ones larger and situated in a lightly pigmented area. Mandibles .4 mm. long, .24 mm. wide at the base, the apex with four stout teeth. Maxillae (fig. 70) with the palpi 45 μ long, the galeae 80 μ long, somewhat horn-shaped, the lacinial area strongly spinulose. Labium (fig. 72) with the apex of the prementum papillose, the palpi about 40 μ long.

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[4] As of this writing, no adults have been reared from the series of larvae of which the specimen described here forms a part. However, there is no doubt that it is a *Podium*, and in all probability *carolina*.

Material.—A single specimen taken in a trap nest at Kill Devil Hills, N. C., Sept. 23, 1955 (K. V. Krombein).

Podium flavipenne Latreille

Williams (1928, Bull. Hawaiian Sugar Planters' Assoc. Exp. Sta., Ent. Ser., no. 19, p. 121 and pl. XVIII, fig. 186), in reporting his observations on the biology of this species in British Guiana, has presented a brief description of the larva. It is described as being about 21 mm. long, the female larger than this, the head nearly white except for the mandibles and a few dark blotches. The body is said to be "well divided"; the first segment has "two pairs of chitinized convexities, the second has but one pair". A sketch of the anterior end of the larva shows these convexities. Thus Williams' description, as far as it goes, agrees perfectly with *Podium carolina*, and confirms the generic value of the sclerotized thoracic convexities.

Explanation of Figures

In all figures of the labrum, the upper or aboral surface is shown on the left side, the under or adoral surface (epipharynx) is shown on the right side. In many figures of the head, the anterior aspect is shown on the left, the posterior on the right. In figures of the apex of the labium, only the right half is shown.

Plate I

Fig. 1.—*Sphex ichneumoneus* (Linnaeus). Head.
Fig. 2.—Same, portion of integument of prothorax, greatly magnified.
Fig. 3.—Same, body.
Fig. 4.—Same, antenna.
Fig. 5.—Same, labrum and epipharynx.
Fig. 6.—Same, apex of maxilla.
Fig. 7.—Same, apex of labium.
Fig. 8.—Same, spiracle.

Plate II

Fig. 9.—*Sphex pensylvanicus* Linnaeus. Labrum and epipharynx.
Fig. 10.—Same, antenna.
Fig. 11.—Same, apex of maxilla.
Fig. 12.—*Palmodes daggyi* (Murray). Labrum and epipharynx.
Fig. 13.—Same, antenna.
Fig. 14.—Same, apex of maxilla.
Fig. 15.—*Prionopyx atratus* (Lepeletier). Head.
Fig. 16.—Same, antenna.
Fig. 17.—Same, apex of maxilla.
Fig. 18.—Same, portion of integument of prothorax, greatly magnified.
Fig. 19.—Same, labrum and epipharynx.
Fig. 20.—Same, apex of labium.

Plate III

Fig. 21.—*Prionopyx thomae* (Fabricius). Labrum and epipharynx.
Fig. 22.—Same, mandible.
Fig. 23.—*Isodontia harrisi* (Fernald). Head.
Fig. 24.—Same, antenna.
Fig. 25.—Same, body.
Fig. 26.—Same, labrum and epipharynx.
Fig. 27.—Same, spiracle.
Fig. 28.—Same, apex of maxilla.

Plate IV

Fig. 29.—*Isodontia azteca* (Saussure). Labrum and epipharynx.
Fig. 30.—Same, apex of maxilla.
Fig. 31.—*Isodontia auripes* (Fernald). Labrum and epipharynx.
Fig. 32.—Same, apex of maxilla.

Fig. 33.—*Podalonia clypeata* Murray. Head.
Fig. 34.—Same, mandible.
Fig. 35.—Same, antenna.
Fig. 36.—Same, body.
Fig. 37.—Same, labrum and epipharynx.
Fig. 38.—Same, apex of maxilla.

PLATE V

Fig. 39.—*Ammophila procera* Dahlbom. Head.
Fig. 40.—Same, portion of integument of prothorax, greatly magnified.
Fig. 41.—Same, antenna.
Fig. 42.—Same, body.
Fig. 43.—Same, labrum and epipharynx.
Fig. 44.—Same, mandible.
Fig. 45.—Same, mandible of another individual.
Fig. 46.—Same, mandible of another individual.
Fig. 47.—*Ammophila urnaria* Dahlbom. Labrum and epipharynx.
Fig. 48.—Same, antenna.
Fig. 49.—Same, mandible.

PLATE VI

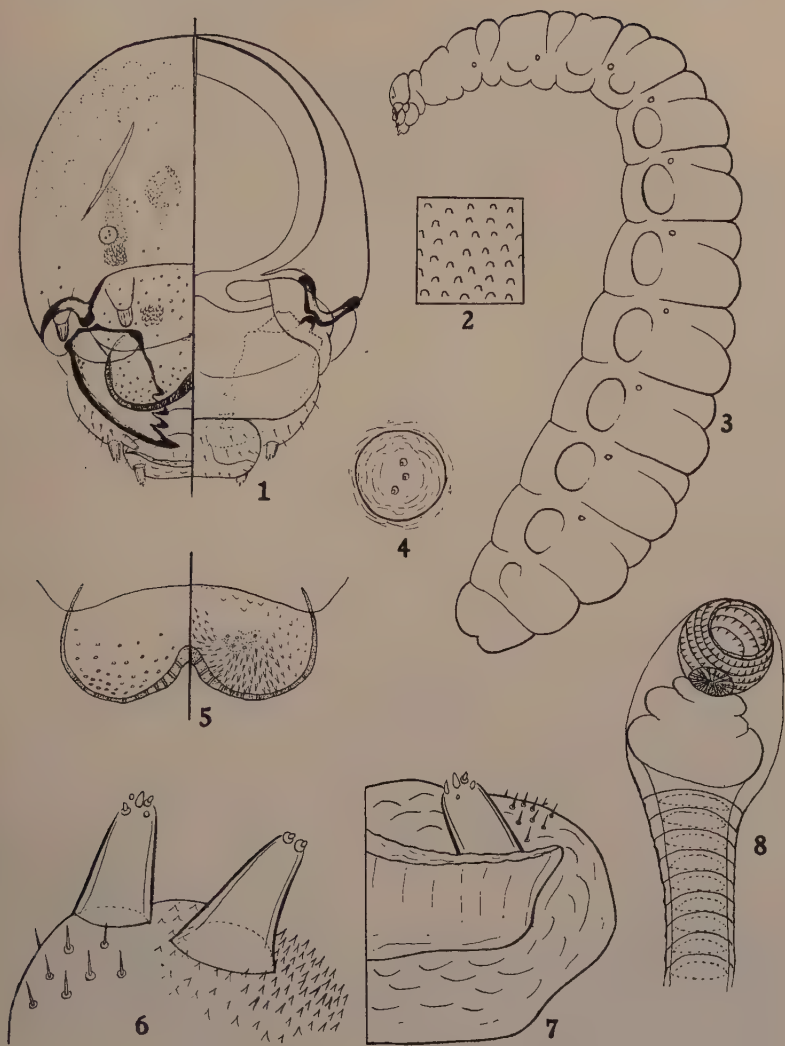
Fig. 50.—*Sceliphron caementarium* (Drury). Head.
Fig. 51.—Same, antenna.
Fig. 52.—Same, body.
Fig. 53.—Same, labrum and epipharynx.
Fig. 54.—Same, apex of maxilla.
Fig. 55.—Same, apex of labium.
Fig. 56.—Same, spiracle and trachea.

PLATE VII

Fig. 57.—*Ammophila harti* (Fernald). Labrum and epipharynx.
Fig. 58.—Same, antenna.
Fig. 59.—Same, mandible.
Fig. 60.—*Ammophila juncea* Cresson. Labrum and epipharynx.
Fig. 61.—Same, antenna.
Fig. 62.—Same, mandible.
Fig. 63.—*Sceliphron assimile* (Dahlbom). Labrum and epipharynx.
Fig. 64.—Same, apex of maxilla.
Fig. 65.—*Chalybion californicum* (Saussure). Labrum and epipharynx.
Fig. 66.—Same, apex of maxilla.

PLATE VIII

Fig. 67.—*Chalybion californicum* (Saussure). Apex of labium.
Fig. 68.—Same, head.
Fig. 69.—*Podium carolina* Rohwer. Head.
Fig. 70.—Same, apex of maxilla.
Fig. 71.—Same, body.
Fig. 72.—Same, apex of labium.
Fig. 73.—Same, labrum and epipharynx.



Sphex ichneumoneus (Linnaeus)

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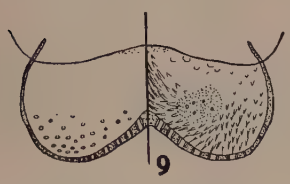
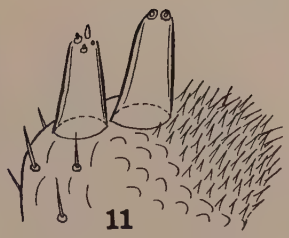
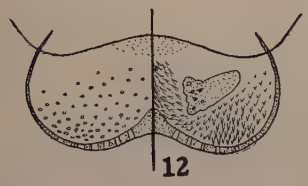
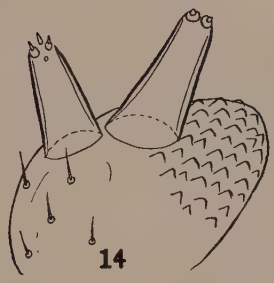


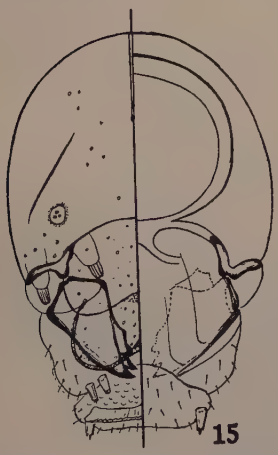


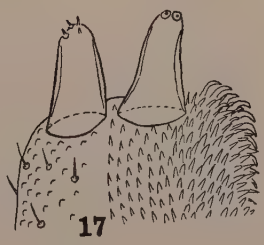
Sphex pensylvanicus Linnaeus

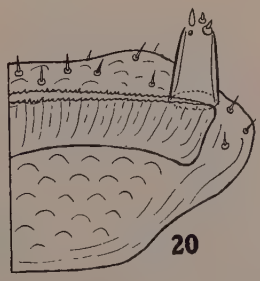


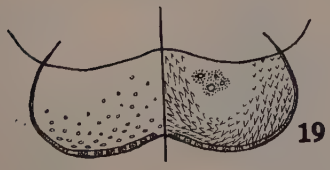


Palmodes daggyi (Murray)









Prionopyx atratus (Lepeletier)

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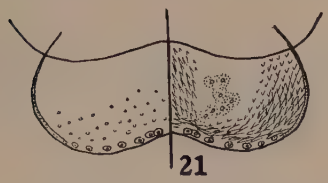
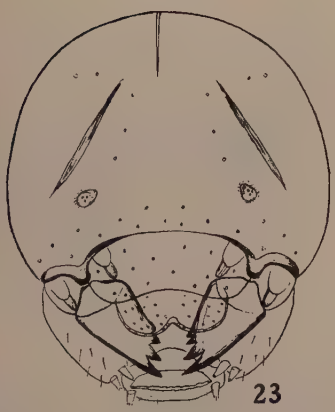
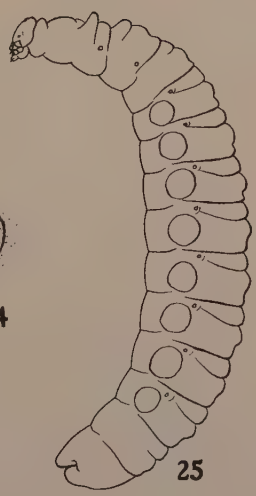
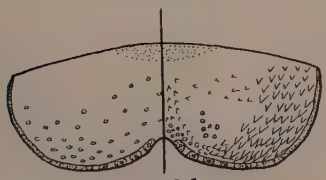
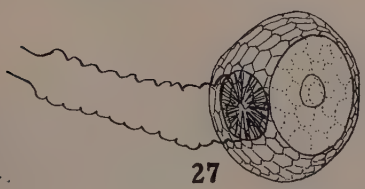


Prionoryx thomae (Fabricius)









Isodontia harrisi (Fernald)

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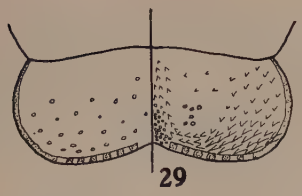
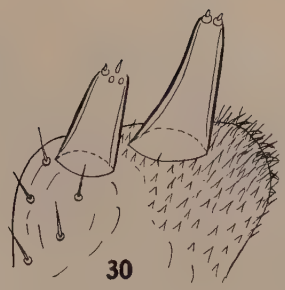
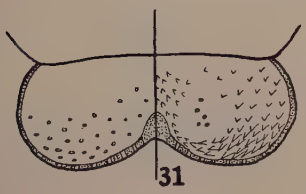
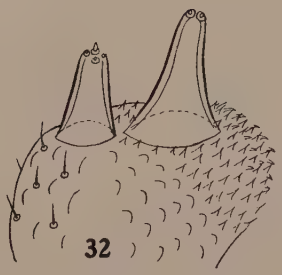


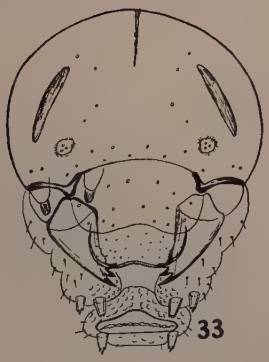
Isodontia azteca (Saussure)

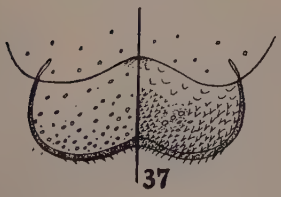


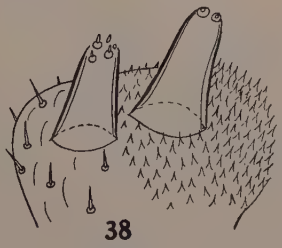


Isodontia auripes (Fernald)

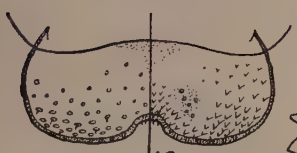




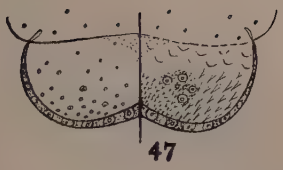




Podalonia clypeata Murray



Ammophila procera Dahlbom



Ammophila urnaria Dahlbom

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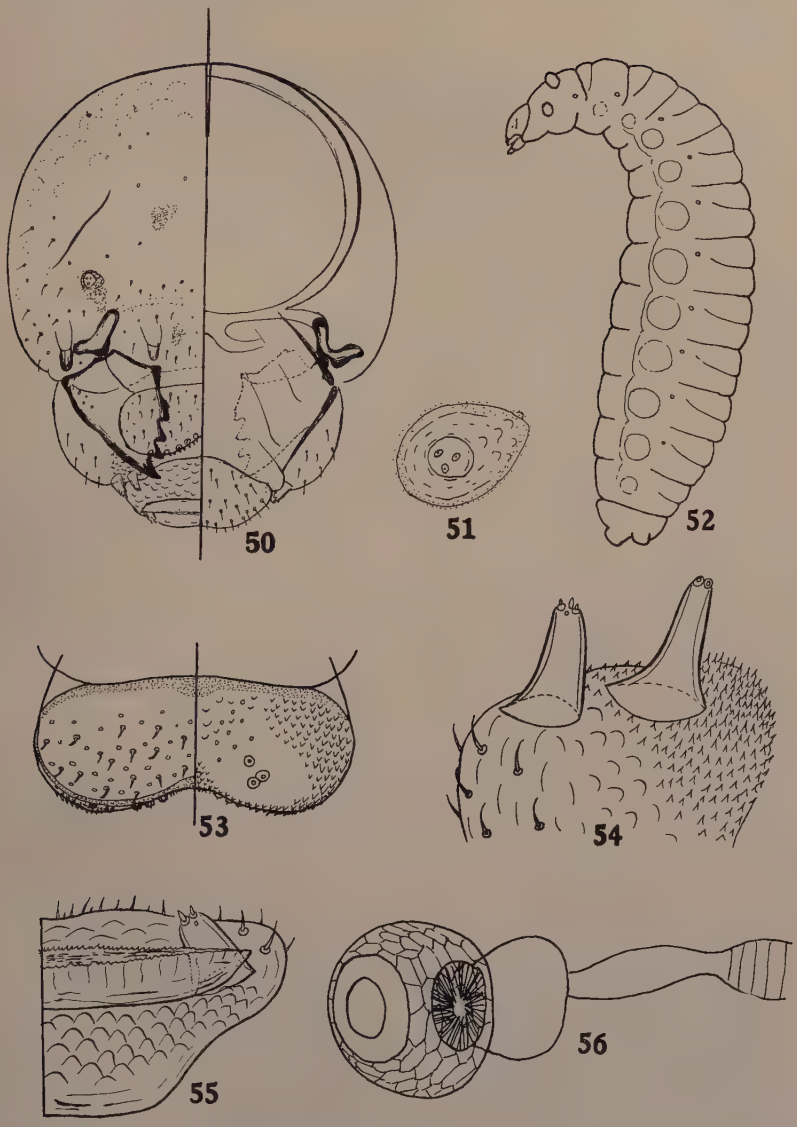

Sceliphron caementarium (Drury)

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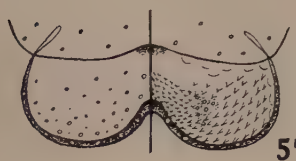
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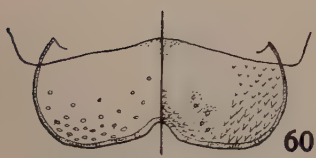
Ammophila harti (Fernald)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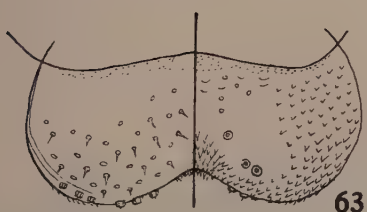
Ammophila juncea Cresson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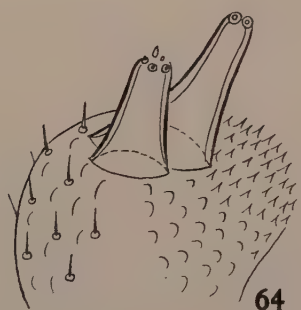
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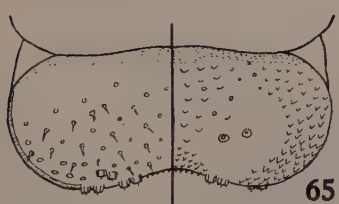
Sceliphron assimile (Dahlbom)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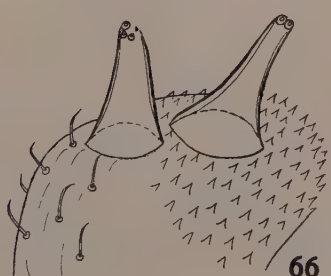
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Chalybion californicum (Saussure)

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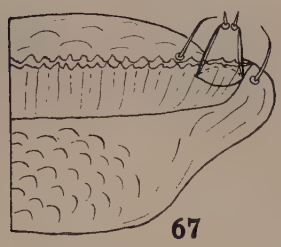
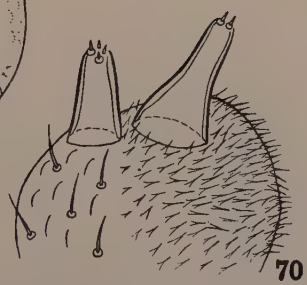
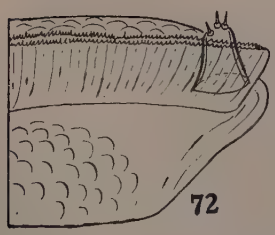
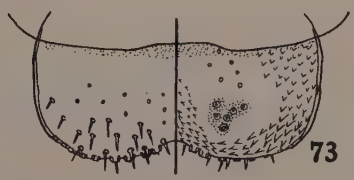


Chalybion californicum (Saussure)







Podium carolina Rohwer

EVANS AND LIN: LARVAE OF DIGGER WASPS

THE UTILIZATION OF MANDIBULAR ARMATURE IN TAXONOMIC STUDIES OF ANISOPTEROUS NYMPHS[1]

BY MILDRED CONOVER WATSON

Department of Zoology, Tulane University of Louisiana, New Orleans

The labium of dragonfly nymphs has long been used in differentiating species and the higher categories. Numerous figures and descriptions are available. Perhaps odonatologists have relied too completely on the labium and have neglected to investigate other structures of possible taxonomic value.

The mandibles and maxillae have received relatively little attention. A series of observations on the maxillae demonstrated no clear generic differences. Hence it was decided to limit this investigation entirely to the mandibles. This study was undertaken to prepare a description of the mandibles of representative genera in each family; to determine whether or not the mandibles can be used for taxonomic purposes; and to ascertain if these structures may yield significant information in regard to phylogeny.

Review of Literature

There is but little general information available. Tillyard (1917),[2] in a general description of the full grown nymph, stated, "The mandibles and maxillae closely resemble those of the imago, except in *Pseudophaea* and *Cora,* where the larval mandibles are biramous." Needham and Heywood (1929) state, "The jaws of nymphs are of a distinct flesh-eating pattern. The mandibles with their z-shaped sharp chitinous ridges[3] cut the victim to pieces,

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[1] A thesis submitted to the Graduate School of Tulane University in partial fulfillment of the requirements for the degree of Master of Science.

[2] Tillyard used the term biramous following Calvert (1911a) who used it to describe the molar crest condition of *Cora.* No species studied has mandibles which are biramous in the usual sense of being homologous to biramous appendages of Crustacea.

[3] These "z-shaped chitinous ridges" were not seen in any of the twenty-seven genera utilized in this study.

while the maxillae shaped like meat forks, turn it conveniently for cutting."

The first detailed descriptions of the nymphal mandible are by Calvert (1911) wherein he described or figured the mandibles of *Cora* and of *Mecistogaster modestus*. Wilson (1918) figured the mandibles of *Anax junius* and of *Erythemis simplicicollis*. Needham (1939) gave a single drawing of a mandible of *Neoneura* but no text description is included. In 1927 Calvert devised a formula to designate the mandibular armature and applied it to descriptions of *Tramea, Erythrodiplax, Erythemis, Orthemis,* and *Pantala*. Nevin (1929) described the mandibles in eleven successive instars for *Sympetrum vicinum*. Lieftinck (1930) described and figured the mandibles of *Nanophlebia ?burensis* and of *?Diplacina phoebe*. Kennedy (1936) described and figured the mandibles in the first and third instars for *Gomphaeschna furcillata*. Geijskes (1943) figured and described the mandibles of nine zygopterous nymphs.

Thus all published material is in the nature of random notes on sundry forms. No one has studied the mandibles in representative genera of the several families.

Materials and Methods

All specimens were from the Entomology Collection of Tulane University except *Ophiogomphus* which was borrowed from the University of Oklahoma, Zoological Sciences Division. All specimens are preserved in 70% alcohol.

The most mature nymph available of each species was always selected for study. Whenever possible last instar exuviae were used, since the absence of internal structures increased the clarity of details.

An examination of the 6th, 8th, 11th, and 13th instars of a reared series of *Pachydiplax longipennis* revealed that any stage before the 8th instar is difficult to study, because of the small size. Any stage earlier than the 6th instar would require a higher magnification and different methods from those described. The major characters are apparently established by the 8th instar. However, certain small teeth and fusions are apparent only after the 11th instar.

All observations and drawings were with a Spencer stereoscopic microscope with 15X oculars and 0.7X, 2X, and 4X objectives. One ocular was equipped with a net reticule ruled into 0.5 mm. squares. Drawings were made with the aid of the reticule and cross section paper.

For study it was necessary to move the mandible but it was only rarely expedient to remove it entirely. By inserting a dissecting needle under the apex it could be lifted into positions in which it was possible to view all surfaces and teeth. When lifted, the mandible remained attached at the posterior condyle and with reasonable care could be returned to its original position after study. Nearly all details of mandibular armature could be studied without damaging the specimen.

It was sometimes difficult to keep the mandible in the desired position for drawing. Fine insect mounting pins size 3 inserted in size 00 vial corks were used for this purpose. The pins were fine enough so that no critical features were covered, and the corks provided sufficient weight for holding the mandible in place. When drawing the inner surface it was advantageous to turn the nymph slightly to one side.

Calvert (1927) pointed out that there are certain constant differences between the right and the left mandibles. This was found to be the case after observing a random sample of genera. Therefore separate descriptions and drawings were necessary for both the right and the left mandibles of each form studied. Four drawings were made for each species: the posterior surface of both right and left mandibles; the inner or medial toothed surface of both right and left mandibles.

Only a limited number of individuals were studied. However, in every case the salient features were apparent in every specimen studied.

General Description

The general features of the mandible are shown in Figures 1-8. It is a stout, roughly pyramidal structure with a triangular base. The inner or medial surface bears two sets of teeth, the distal, apical incisors and the proximal molars. In the Gomphidae, Aeschnidae, and Cordulegasteridae the molars constitute a single ridge or

crest which is almost parallel to the incisors. In the other families the molars are single teeth variously arranged.

Calvert's (1927) method of designating mandibular armature is used, but with a few additions and modifications. The use of the terms anterior and posterior follow Calvert, but require explanation. Since the dragonfly nymph is prognathous, the term anterior refers to the dorsal surface of the mandible when viewed in the normal position, and posterior refers to the ventral surface.

Figures 1-8 illustrate the use of the formula. Beginning at the anterior margin, the incisors are numbered 1 to 4. A full set of single molars are labeled *a, b, c,* and *d*. If a molar crest is present the most anterior tooth of the crest is designated as *a;* the most posterior tooth, *b;* the teeth between *a* and *b* on the crest are designated *m*. In the formula they are placed within parentheses thus: $a(m^{1,2,3,4})b$. There is an additional tooth on the posterior margin intermediate between the incisors and the molars which is designated *y*. There may be another tooth in a corresponding position on the anterior margin which is *x*. *k* is a denticle on the anterior margin between *a* and the base of the mandible.

Thus the formula for a form with a molar crest (figures 1-4) would be:

$$\frac{L\ 1234\ \ 0\ \ a(m^{1,2})b}{R\ 1234\ \ y\ \ a(m^{1,2})b}.$$

Figures 5-8 illustrate a mandible which does not have a molar crest. The formula for these figures would be:

$$\frac{L\ 1234\ \ 0\ \ ab}{R\ 123{+}4\ \ y\ \ abcd}.$$

If a tooth symbol is followed by a minus sign (–), that tooth is reduced. An 0 in the formula denotes a lack of a particular tooth; and *a* a′ means *a*′ is a smaller tooth closely associated with *a*. 1+2 indicates more or less complete fusion of two teeth.

Lieftinck (1930) used the same letters in the formula as Calvert, but modified their arrangement in regard to the molars. He makes no reference to the rearrangement in the text, but apparently did this to indicate more clearly the relationship of the molars of the left mandible to those of the right. When four molars are present on the right Calvert labels them:

distal

d *c*

anterior

b *a*

Lieftinck designates four molars:

distal

b *c*

anterior

d *a*

With Lieftinck's system, *a* and *b* of the left correspond to *a* and *b* of the right, but with Calvert's, *a* and *b* of the left are seemingly in the same relative position as *a* and *d* of the right. In this study Lieftinck's system is followed because his placement of *a* and *b* also seems to correspond with molars *a* and *b* of the molar crest.

Genera are placed in families according to the classification of Tillyard and Fraser (1938, 1939, 1940).

A preface to each family or subfamily includes a general formula for the group and characters which are common to all the genera studied in each group. At the close of each family or subfamily the phylogenetic trends within the group are discussed. These trends are summarized in figure 117.

In the description of each genus the mandibular characters are incorporated into the following outline:

A. Molars

With molar crest.

1. Shape of the crest and its height (whether greater than, equal to, or shorter than the incisors).
2. Size of the individual teeth of the crest.
3. Shape of the individual teeth.

Without a molar crest.

1. Size of the molars.
2. Shape of the molars.

B. Incisors

1. Shape of margins (angulate or tapered).
2. Comparative extent of the teeth when all are considered collectively. This does not refer to the actual length of

the individual incisors measured from base to apex.

3. Comparative prominence.
4. Shape and/or size of particular incisors or comparison of particular incisors on the same mandible.
5. Presence of additional incisors.

C. Additional teeth

1. *y*
2. *k*
3. *x*

If any of the characters in the preceding outline is common to all members of a family, this is stated in the preface to each family and is not repeated in the individual descriptions. A character may also be omitted from the description if its presence or absence is diagnostic in itself and this information is evident from the formulas. All statements refer to both the right and left mandibles unless stated otherwise.

Description of Genera

GOMPHIDAE

Genera studied: *Hagenius* Selys, *Gomphus* Leach, *Dromogomphus* Selys, *Ophiogomphus* Selys, and *Progomphus* Selys.

General formula for the family:

$$\frac{\text{L } 1\,2\,3\,4 \quad 0 \quad a(m^{1,2,3,4 \text{ or } 1,2,3,4,5})b}{\text{R } 1\,2\,3\,4 \quad y \quad a(m^{1,2 \text{ or } 1,2,3 \text{ or } 1,2,3,4 \text{ or } 1,2,3,4,5,6})b}$$

The following characters were found in all of the genera studied:

1. A molar crest with from four to eight teeth is present. The crest is as high as or higher than the incisors.
2. The anterior and posterior margins of the left incisors are not uniformly tapered, but are angulate.
3. Tooth *y* is always present on the right mandible, but is never present on the left.

Hagenius brevistylus Selys — Figures 9, 10, 11, 12

Material studied.—One nymph from Greensburg, Tickfaw River, St. Helena Parish, La.; one exuvium from Kentwood, Tangipahoa Parish, La.

Mandibular formula:

$$\frac{L\ 1\,2\,3\,4\ \ 0\ \ a(m^{1-4})b}{R\ 1\,2\,3\,4\ \ y\ \ a(m^{1-4})b}$$

Left

A. 1. The molar crest straight and is higher than the incisors.
2. $a > b$; a and $b > m$.
3. m are more pointed than a and b.

B. 1. Teeth 2 and 3 of the incisors are not uniformly tapered, but are angulate.

Right

A. 1. The molar crest is straight and is higher than the incisors.
2. All the teeth of the molar crest are the same size.
3. Teeth m are more sharply pointed than the corresponding teeth on the left mandible.

B. 1. The incisors are tapered.

Gomphus sp. Figures 13, 14, 15, 16

Material Studied.—One nymph from Marion, Union Parish, La.

Mandibular formula:

$$\frac{L\ 1\,2\,3\,4\ \ 0\ \ a(m^{1-4})b}{R\ 1\,2\,3\,4\ \ y\ \ a(m^{1-4})b}$$

Left

A. 1. The base of the molar crest is curved. The middle of the curve is toward the incisors. The crest is higher than the incisors.
2. $a > b > m$.
3. a and b are pointed, and m are rounded.

B. 1. None of the incisors is uniformly tapered to a single point.
2. $4 > 3 > 2 > 1$.

Right

A. 1. The molar crest is approximately the same height as the incisors. The base of the crest is slightly curved, as in the left. The distal margin curves slightly proximally, but less than the left.
2. $a > b > m$.
3. a and b are pointed: m, rounded. The clefts between m are deeper on the left mandible than on the right, i.e., those

teeth are more prominent on the left.

B. 1. All the incisors are tapered.
2. $3 > 4 > 1 = 2$.

Dromogomphus spinosus Selys — Figures 17, 18, 19, 20

Material studied.—Two nymphs from St. Tammany, St. Tammany Parish, La.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad a(m^{1,2,3,4 \text{ or } 1,2,3,4,5})b}{\text{R } 1234 \quad y \quad a(m^{1,2,3,4 \text{ or } 1,2,3,4,5,6})b}$$

Left

A. 1. The base of the molar crest is curved. The middle of the curve is toward the incisors. The crest is higher than the incisors.
2. $a > b > m$.
3. m are slightly tapered, but the ends are rounded.

B. 1. None of the incisors is uniformly tapered.
2. $3 > 4 > 1 > 2$ or $3 = 4 > 1 > 2$.

Right

A. 1. The molar crest is curved as in the left, and is higher than the left.
2. $a > b > m$.
3. m are pointed.

B. 1. Incisors 3 and 4 are uniformly tapered to a sharp tip.
2. $4 > 3 > 2 > 1$.

Ophiogomphus sp. — Figures 21, 22, 23, 24

Material studied.—One nymph from Johnston County, Okla.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad a(m^{1,2,3,4})b}{\text{R } 1234 \quad y \quad a(m^{1,2,3,4})b}$$

Left

A. 1. The base of the molar crest is curved. The middle of the curve is toward the incisors. The crest is higher than the incisors.
2. $a > b > m$.
3. a and b are pointed; m are rounded.

B. 1. All of the incisors are angulate.
2. $4 > 3 > 1 > 2$.

Right

A. 1. The molar crest is curved, but less than in the left, and is markedly smaller. The crest is not as high as the incisors.
2. $a > b$.
3. a and b are both sharply pointed. m are sharply pointed and are smaller in proportion to a and b than the corresponding teeth on the left.

B. 1. All the incisors are angulate; the angle in the posterior margin of 1 is more prominent than in the other incisors. All the tips are rounded.
2. $4 > 3 > 2 > 1$.

Progomphus obscurus (Rambur) Figures 25, 26, 27, 28

Material studied.—Two nymphs from St. Tammany, St. Tammany Parish, La.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad a(m^{1,2,3,4})b}{\text{R } 1234 \quad y \quad a(m^{1,2 \text{ or } 1,2,3})b}$$

Left

A. 1. The molar crest is set in a soft, fleshy area. The crest extends above the incisors.
2. $a > b > m$.
3. m are rounded.

B. 1. None of the incisors is tapered uniformly.
2. $4 > 3 = 2 = 1$.

Right

A. 1. The molar crest is greatly reduced, set in a soft, fleshy area, and curves toward the proximal margin.
2. $b > a = m$.
3. b is a long pointed tooth, but a, m are short and rounded.

B. 1. All the incisors are stronger than on the left. Incisors 1 and 2 are not uniformly tapered; 3 and 4 are more uniform.
2. $4 > 3 = 1 > 2$.

The outstanding feature of the Gomphidae is the molar crest which is always as high as or higher than the incisors. Primarily

on the basis of this crest (size of crest, size of teeth on crest, and number of teeth) the genera have been placed in a series as follows: *Hagenius, Dromogomphus, Gomphus, Ophiogomphus, Progomphus.* The most marked trend in this series is the reduction of the size of the teeth between *a* and *b* and the reduction of the crest itself.

Another change is in the shape of the teeth of the molar crest. All the molars of the right mandible of *Hagenius* are about the same size and are sharply pointed. The base of the crest is straight.

Dromogomphus and *Gomphus* are similar to each other. In both, *a* and *b* are much larger in proportion to *m* than they are in *Hagenius.* The molar crest is not as heavy as in *Hagenius,* and the base of the crest is not straight, but curved.

In the preceding members of this series, the crest has been essentially equal in size on both the right and left. In *Ophiogomphus,* however, the right crest is smaller than the left. Further reduction in the size of the molar crest occurs in *Progomphus.* The crests of *Progomphus* are set high in soft, fleshy areas. The right crest is smaller in proportion to the left than those of *Ophiogomphus.* Only four teeth are present on the right crest, which is the least number in this family.

CORDULEGASTERIDAE

Genus studied: *Cordulegaster* Leach.

Cordulegaster sp. Figures 29, 30, 31, 32

Material studied.—One nymph and one exuvium from Semmes, Mobile County, Ala.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad a(m^{1,2,3 \text{ or } 1,2,3,4})b}{\text{R } 1234 \quad y \quad a(m^{1,2,3,4 \text{ or } 1,2,3,4,5})b}$$

Left

A. 1. The molar crest is as high as the incisors; its base is straight.
   2. $a > b > m$.
   3. *a* is sharply pointed; *b* is slightly rounded at the tip; *m* is rounded.

B. 1. The incisors are usually uniformly tapered, but 1, 2, and 4 may be slightly angulate. All are sharply pointed.

2. $4 = 3 > 2 > 1$.

The molar crest and the apical margin form a 50-60° angle; the apex of the angle is anterior. The base of the cleft between molar *a* and incisor 1 is angular or only slightly rounded.

Right

A. 1. The molar crest is higher than the incisors. The base is straight.
   2. $a > b > m$.
   3. *a* and *b* are pointed; *m* are rounded.

B. 1. Incisor 4 is always smoothly tapered; 1, 2, and 3 are slightly angulate. All terminate in a sharp point.
   2. $4 > 3 > 2 > 1$.

The incisors and the crest do not come together at an angle anteriorly as in the left, but are subparallel. Molar *a* and incisor 1 are not adjacent, but are separated by a wide, deep cleft which is rounded at its base.

3. *y* is sharply pointed.

The Cordulegasteridae are considered primitive because the molar crest is well developed and bears approximately the same number of teeth as in Gomphidae.

AESCHNIDAE

Genera studied: *Boyeria* Maclachlan, *Coryphaeschna* Williamson, *Epiaeschna* Hagen, *Nasiaeschna* Selys, and *Anax* Leach.

General formula for all genera except *Anax:*

$$\frac{\text{L } 1234 \quad 0 \quad a(m^{0,1})b}{\text{R } 1234 \quad y \quad a(m^{0,1})b}$$

The following characters were found in all of the genera studied:

1. Both the right and left mandibles have a molar crest with two prominent teeth, *a* and *b*. The total number of teeth varies from two to six. Tooth *a* is always larger than *b*.
2. The molar crest is as high as or higher than the incisors.
3. Of the incisors of both the right and left mandibles, 3 is the highest, 2 and 4 are approximately the same height, and 1 is the shortest.

4. There are no abrupt breaks in the margins of the left incisors. The incisors are not angulate.
5. Tooth *y* is always present on the right mandible, but is never present on the left except in *Anax*. *y* is always smaller than any of the incisors or molars.

Boyeria vinosa (Say) Figures 33, 34, 35, 36

Material studied.—Two nymphs from St. Tammany, St. Tammany Parish, La.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad a(m?)b}{\text{R } 1234 \quad y \quad a(m^{1,2,3,4})b}$$

Left

A. 1. The molar crest is about as high as the incisors.
2. *a* and *b* > *m*. The edge of the crest between *a* and *b* is crenulate; the number of teeth is indefinite.
3. *a* and *b* are not sharply pointed.

B. 1. All the incisors are tapered.

Right

A. 1. The molar crest is higher than the incisors.
2. *a* and *b* are larger and more prominent than *m*.
3. All the teeth of the crest are pointed.

B. 1. All the incisors are tapered and more pronounced than on the left (the clefts between them are deeper).

Coryphaeschna ingens (Rambur) Figures 37, 38, 39, 40

Material studied.—One nymph from Florenville, St. Tammany Parish, La.; one nymph from Arcola, Tangipahoa Parish, La.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad abk}{\text{R } 1234 \quad y \quad a(m^{1})bk}$$

Left

A. 1. The molar crest is prominent and extends above the incisors.
2. There is a swelling on the posterior margin of *a*, but not of proportions to constitute a separate tooth.
3. *a* and *b* are sharply pointed. The tip of *b* bends proximally.

B. 1. Teeth 3 and 4 are tapered to a sharp point; 2 is blunt; and 1 is slightly angulate on the posterior margin.

C. 3. Tooth *k* is small and blunt.

Right

A. 1. The molar crest is higher than the incisors.
2. m^1 is a small tooth on the posterior margin of *a*.
3. All the teeth on the crest are pointed.

B. 1. Teeth 3 and 4 are uniformly tapered to a sharp point, but 1 and 2 are angulate.
2. Tooth 3 is a slender structure much higher than the other three incisors.
3. *k* is larger than on the left. It is not pointed, but is flattened, with a broad base.

Epiaeschna heros (Fabricius) Figures 41, 42, 43, 44

Material studied.—One nymph from Covington, St. Tammany Parish, La.; one nymph from Lafayette, Lafayette Parish, La.

Mandibular formula:

L	1 2 3 4	y–	a(m–)b
R	1 2 3 4	y	a b k

Left

A. 1. The molar crest is higher than the incisors.
2. *a* and *b* are more pointed than *m*–.

B. 1. All the incisors are uniformly tapered.
2. 3 is narrower and more rounded at the tip than the other incisors.

C. 1. *y* is a small, rounded protrusion of the posterior margin.

Right

A. 1. The molar ridge is higher than the incisors.
2. *a* and *b* form either end of the crest. There are no intermediate teeth *m*.
a is much larger than *b*.
3. *a* and *b* are both sharply pointed.

B. 1. All the incisors are tapered to a sharp point.

C. 1. *y* is more prominent than on the left.
2. *k* is sharply pointed.

Nasiaeschna pentacantha (Rambur) Figures 45, 46, 47, 48

Material studied.—Two nymphs without locality data.

Mandibular formula:

$$\frac{\text{L } 1\,2\,3\,4 \quad 0 \quad a\,b\,k}{\text{R } 1\,2\,3\,4 \quad y \quad a\,b\,k}$$

Left

A. 1. The molar crest is as high as or higher than the incisors and consists only of teeth *a* and *b*. (The whole crest is a high two-armed structure, *a* and *b* forming the pointed arms.)

3. *a* and *b* are both pointed.

B. 1. Only tooth 4 is uniformly tapered.

C. 3. *k* is rounded.

Right

A. 1. The molar crest is as high as or higher than the incisors. There is a clear-cut intervening portion of the crest separating *a* and *b*.

2. The margin between *a* and *b* is serrate. This margin slants down to the base of *b*.

B. 1. None of the apical teeth is uniformly tapered.

C. 3. *k* is not as large as on the left, but is more pointed than the left *k*.

Anax junius (Drury) **Figures 49, 50, 51, 52**

Material studied.—Three nymphs from Pearl River, St. Tammany Parish, La.

Mandibular formula:

$$\frac{\text{L } 1\,2\,3\,4 \quad y- \quad a\,b\,k}{\text{R } 1\,2\,3\,4 \quad y \quad a\,a'\,b\,b'\,k}$$

Left

A. 1. The crest is higher than the incisors.

2. The margin of the crest between *a* and *b* is straight.

3. *a* and *b* are rounded; *b* is more blunt than *a*.

B. 1. None of the incisors has a straight margin, but curves slightly outward at its base.

C. 1. *y* is greatly reduced; it is but a slight rounded enlargement on the posterior margin.

Right

A. 1. The molar crest is as high as or only slightly higher than the incisors.

2. $a > b$. a' is on the posterior margin of a: b' is located just proximal to b.

3. All the molars are pointed.

B. 1. The right incisors are more slender and pointed than the left.

The Aeschnidae possess a molar crest and this structure shows the major differences among the genera. These differences indicate that *Boyeria* is the most primitive of this group and that *Anax* is the most advanced. The complete series appears to be: *Boyeria, Coryphaeschna, Epiaeschna, Coryphaeschna, Anax.*

The molar crest of *Boyeria* is essentially as in Gomphidae. Neither the left nor the right crest is as small as the right crest of *Progomphus.* The trend noted in the Gomphidae of a being larger than b is continued in the Aeschnidae and most of the intervening teeth (m) disappear. In the left mandible of *Coryphaeschna* there are no teeth between a and b. The posterior margin of a is curved upward, which is suggestive of the teeth m of *Boyeria.* On the posterior margin of a on the right is a small tooth which appears to be homologous to m^1.

In *Epiaeschna,* but not in *Nasiaeschna,* the margin between a and b on the left is curved as in *Coryphaeschna.* In *Epiaeschna* k is present on the right only; in *Nasiaeschna* k is present on both right and left.

The molar crest of *Anax* is straight, not curved as in preceding members of this series. On the left mandible there are no teeth between a and b. There are four teeth on the right mandible in the molar area which, on the basis of number only, appears to be a more primitive characteristic. But *Anax* is considered to be the most advanced because of the position of these teeth. a' is on the posterior margin of a, as in *Coryphaeschna,* but b' is proximal to b, not in line with the molar crest. This is the first instance of a molar being located outside of the molar crest proper and it is possibly an approach to the molar arrangement in the Libellulidae.

Tooth k, a denticle on the anterior margin between the molar crest and the proximal margin, is present for the first time in

Epiaeschna. This tooth was absent in the Gomphidae and Cordulegasteridae. *k* is present on the right in *Epiaeschna,* and is present both right and left throughout the rest of the genera studied in this family. Since this tooth is present only on the right in *Epiaeschna,* and is found both right and left in *Coryphaeschna,* this, coupled with the molar characters, might be sufficient reason for interchanging the positions of *Epiaeschna* and *Coryphaeschna* in the series.

CORDULIIDAE

Subfamily Epophthalmiinae

Genera studied: *Macromia* Rambur and *Didymops* Rambur.

General formula for the subfamily:

$$\frac{\text{L } 1234 \quad 0 \quad ab}{\text{R } 1234 \quad y \quad ab}$$

These characters are present in the two genera studied:

1. The molar crest is absent.
2. Only two molars, *a* and *b*, are present on both the right and left in the position of the molar crest.
   b is always larger than *a*.
3. On the left $3 = 4 > 1 > 2$; on the right $4 > 3 = 1 > 2$.
4. None of the incisors is angulate.
5. In overall size 2 is smaller than any other incisor.
6. *y* is always present on the right, never on the left.

Macromia sp. Figures 53, 54, 55, 56

Material studied.—One exuvium from Tickfaw, Tangipahoa Parish, La.; one nymph from Shipman, Miss.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad ab}{\text{R } 1234 \quad y \quad ab}$$

Left

A. 1. $b > a$.
   2. *b* is more pointed than *a*.
B. 1. The incisors are slender.

Right

A. 1. The molars are both heavier than on the left.

B. 1. The incisors are pointed.

3. The cleft between 3 and 4 is not as deep as on the left.

4. Of the incisors, 1 is broadest at the base, its anterior and posterior margins are approximately equal. The posterior margin of 1 is not smooth.

5. There is a slight rounded elevation between 2 and 1.

Didymops transversa (Say) Figures 57, 58, 59, 60

Material studied.—Two nymphs from Burt Lake, Cheboygan County, Michigan.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad ab}{\text{R } 1234 \quad y \quad ab}$$

Left

A. 1. *a* and *b* are large heavy structures suggestive of the molar crest.

B. 1. All the incisors are rounded except 4 which is pointed.

3. The cleft between 3 and 4 is deeper than on the right.

4. 1 is deeply concave on the proximal surface.

Right

A. 1. The molars are essentially the same as the left.

B. 1. The incisors are more pointed than on the left.

3. The separation between 3 and 4 is less than on the left.

4. 1 is the heaviest incisor, having a broad base approximating the combined bases of 3 and 2. It is not concave as in the left.

In the Epophthalmiinae the molar crest is completely absent for the first time, thus completing the trend of the disappearance of the crest. Two prominent teeth remain in the position of the crest of the preceding groups. These teeth are designated *a* and *b*, because they appear to be homologous to those teeth of the crest.

In Gomphidae and Aeschnidae the incisors all have been approximately the same size, although there has been some variation in extent. In *Macromia,* however, 2 is reduced, and on the right, 1 is broader at the base than the other three incisors. These tendencies

are further accentuated in *Didymops*. The clefts between the incisors are shallower, 2 is more reduced, and the base of 1 is broader.

Subfamily Corduliinae

Genera studied: *Neurocordulia* Selys, *Somatochlora* Selys, and *Tetragoneuria* Hagen.

General formula for the subfamily:

$$\frac{\text{L } 1\,2\,2'\,3\,4 \quad 0 \text{ or } y \quad a\,b}{\text{R } 1\,2\,3\,4 \quad\quad y \quad\quad a\,b\,c}$$

The following characters were found in all the genera studied:

1. A molar crest is absent.
2. Three molars are present on the right.
3. Of the incisors, 3 is the highest on the left; 4 is the highest on the right.
4. On the left mandible a fifth tooth, 2′, is found on the anterior margin of 2. 2′ is never present on the right.
5. On the right, incisor 1 is always broader at the base than either 2, 3, or 4 and is broader than any of the left incisors. On the right 1 the anterior margin is shorter than the posterior margin. Left incisor 1 has both the anterior and posterior margins about equal.

Neurocordulia yamaskanensis (Provancher) Figures 61, 62, 63, 64

Material studied.—Two last instar exuviae from Put-in-Bay, Ottawa County, Ohio.

Mandibular formula:

$$\frac{\text{L } 1\,2\,2'\,3\,4 \quad 0 \quad a\,b'\,b}{\text{R } 1\,2\,3\,4 \quad\quad y \quad a\,b\,d}$$

Left

A. 1. *b* is much heavier than *a*.
   2. *b* has a broad base, and the tip is rounded.

B. 1. All the incisors are sharply pointed.
   2. $3 > 4 = 2 > 1$.
   3. The clefts between the teeth are much deeper than on the right. The teeth are more slender, longer than on the right.
   4. The broadest tooth is 3; 4 is almost as large.

Right

A. 1. *a* and *b* are approximately the same size, with blunt, flat tips.
   2. *b′* is rounded and smaller than *a* and *b*.

B. 1. 4 is rounded; the other incisors are pointed.
   2. $4 = 3 > 2 > 1$.
   3. The individual teeth are smaller than on the left.
   4. The base of 1 is as broad as 2 and 3 together, and wider than 4. Its sides are not equal; the anterior margin is the shorter. The posterior margin of 1 is straight.

Somatochlora linearis (Hagen) Figures 65, 66, 67, 68

Material studied.—Two nymphs from Womack, Jackson Parish, La.

Mandibular formula:

$$\frac{\text{L } 1\,2\,2'\,3\,4 \quad \text{y} \quad \text{a}\,\text{b}'\,\text{b}}{\text{R } 1\,2\,3\,4 \quad \text{y} \quad \text{a}\,\text{b}\,\text{d}}$$

Left

A. 1. The molars are small, sharply pointed teeth. *b′* is in direct line with *a* and *b* and is closer to *b*.

B. 1. The incisors are short, stout and pointed, and curve toward the proximal margin of the mandible.
   2. $3 > 4 > 2 = 1$.

Right

A. 1. The molars are more rounded than on the left.

B. 1. The incisors are pointed.
   2. $4 > 3 > 2 = 1$.
   3. The individual teeth are not as prominent as on the left.
   4. The base of 1 occupies almost half of the apical margin. The posterior margin of 1 is arched, but the tip is pointed.

Tetragoneuria cynosura (Say) Figures 69, 70, 71, 72

Material studied.—Two last instar exuviae and one nymph from Ruston, Lincoln Parish, La.

Mandibular formula:

$$\frac{\text{L } 1\,2\,2'\,3\,4 \quad \text{y}- \quad \text{a}\,\text{b}}{\text{R } 1\,2\,3\,4 \quad \text{y} \quad \text{a}\,\text{b}\,\text{d}}$$

Left

A. 1. *b* is larger than *a*.
   2. *b* is rounded at the tip.

B. 1. The incisors are tapered, but not sharply pointed.
   2. $3 > 4 > 2 > 1$. 1, 3, and 4 are long. 2 and 2′ are inconspicuous.
   3. The base of the cleft between 3 and 4 is rounded; between 1 and 2+2′ is a sharp angle.
   4. The combined bases of 3 and 4 occupy more than half the apical margin.
   5. 2 is greatly reduced. Both 2 and 2′ are small.

Right

A. 1. *a* and *b* are slightly pointed and about the same size.
   2. *b′* is flattened at the tip.

B. 1. The incisors are rounded.
   2. $4 > 3 > 1 = 2$.
   3. The deepest cleft is between 1 and 2. The cleft between 3 and 4 is much smaller than on the left. The bases of all the clefts are rounded.
   4. The base of 1 occupies almost half of the apical margin.

There are three molars on the right mandible in all of the Corduliinae, a condition which first appeared in *Anax*. In the Corduliinae this third molar is closer to *b* than to *a* and is never in direct line with *a* and *b*. The number and arrangement is essentially as in *Anax*.

The Corduliinae are placed in a series as follows: *Neurocordulia, Somatochlora,* and *Tetragoneuria*. One reason for this order is that *y* is lacking on the left mandible of *Neurocordulia,* as in previous families, but is present in *Somatochlora* and *Tetragoneuria* on both right and left.

Another character which points toward the order given is the progressive reduction of 2 and 2′. 2′ is a small, but distinct tooth at the base of 2, almost appearing to be in the cleft between 1 and 2 in *Neurocordulia*. 2′ is also present in *Somatochlora,* but is on the anterior margin of 2 rather than at its base in the cleft. In *Tetragoneuria,* 2′ is higher on the anterior margin than in *Somatochlora,* but both 2 and 2′ are greatly reduced.

A feature of the right mandible which substantiates this arrangement is the progressive broadening and increasing stoutness of the first incisor. The base of the first incisor in *Neurocordulia* occupies about one-third of the apical margin. In *Somatochlora* the base of the first incisor of the right takes up about one-half of the apical margin. In *Tetragoneuria* this incisor is slightly larger than in *Somatochlora*.

LIBELLULIDAE

Genera studied: *Orthemis* Hagen, *Ladona* Needham, *Perithemis* Hagen, *Cannacria* Kirby, *Sympetrum* Newman, *Celithemis* Hagen, *Plathemis* Hagen, *Pachydiplax* Brauer, *Erythemis* Hagen, *Tramea* Hagen, and *Pantala* Hagen.

There is no general formula which will apply to all of the above genera, but the following characters were common to all.

1. A molar crest is absent.
2. At least two molars, *a* and *b* are always present on the left. *b* is always larger than *a*. At least three molars are always present on the right.
3. When four incisors are present on the left, 3 is longer than 4 and $4 > 2 > 1$, except in *Cannacria*. When three incisors are present on the left $3 > 2$. $2 > 1$ or $2 = 1$. When four incisors are present on the right, 3 is always longer than 4; if there are three incisors, 3 is the longest.
4. In regard to incisors, the left mandible is more strongly toothed than the right.
5. *y* is present on the right and is sometimes present on the left.

Orthemis ferruginea (Fabricius) Figures 73, 74, 75, 76

Material studied.—One nymph from Enchanted Rock, Llano County, Texas.

Mandibular formula:

L	1 2′ 2 3 4	0		a b
R	1 2 3+4		x y	a b d

Left

A. 1. *b* is larger than *a*.
2. Both *a* and *b* are pointed.

B. 1. The incisors are tapered but do not terminate in sharp points.
2. $3 > 4 > 2 > 1$.
3. The clefts between the incisors are deeper than on the right. Hence, the teeth of the left mandible are more prominent.
4. 1 is slender.
5. 2′ is on the anterior margin of 2.

Right

A. 1. $d > b > a$.
2. The molars are heavy with broad bases.

B. 1. The margins of the incisors are slightly rounded. The apex of 2 is rounded, but the other three incisors are more pointed.
2. $4 > 3 > 1 > 2$ or $1 = 2$.
3. The incisors are less distinct than on the left.
4. The base of 1 is broader than the base of either of the other incisors.

C. 1. y is small and blunt.
3. A small protuberance at the base of 1 on the anterior margin is designated as x. However, it is much nearer to the incisors than is implied in the definition of "intermediate between the incisors and molars."

This description of *Orthemis ferruginea* agrees with Calvert's (1927) description.

Ladona deplanata (Rambur) Figures 77, 78, 79, 80

Material studied.—One last instar exuvium from Ruston, Lincoln Parish, La.

Mandibular formula:

$$\frac{\text{L } 123{+}4 \quad 0 \quad ab}{\text{R } 123{+}4 \quad y \quad abd}$$

Left

A. 1. $b > a$.
2. a and b are both sharply pointed.

B. 1. All the incisors are pointed; 3 and 4 are more sharp than 1 and 2.
2. $3 > 4 > 2 > 1$.

3. The cleft between 3 and 4 is deeper than on the right.
4. 1 curves proximally more than 2, 3, or 4.

Right

A. 1. $d > a = b$.
2. All the molars are pointed.

B. 1. The incisors are not uniformly tapered.
2. $4 > 3 > 1 > 2$.
3. 3 and 4 are almost completely fused, but there is a small cleft between their apices.
4. Base of $1 = 3+4 > 2$.

Perithemis tenera (Say) Figures 85, 86, 87, 88

Material studied.—One nymph from New Orleans, La.; two last instar exuviae from Fluker, Tangipahoa Parish, La.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad abd}{\text{R } 1234 \quad y \quad abd}$$

Left

A. 1. $b > a = d$. b is heavy and blunt.

B. 1. The incisors are tapered to sharp points.
2. $3 > 4 > 2 > 1$.
4. The base of 1 is approximately as wide as that of each of the other incisors.

Right

A. 1. $b > a = d$.
2. a is sharply pointed; d is less sharply pointed; b is blunt.

B. 1. All the incisors are tapered to sharp points.
2. $4 > 3 > 2 > 1$.
3. The clefts between the incisors are not as deep as on the left. The fusion of 3 and 4 is much less than on the left.
4. The base of $3+4 > 2 = 1$.

Cannacria gravida (Calvert) Figures 81, 82, 83, 84

Material studied.—One nymph from New Orleans, La.; one last instar exuvium from Hollywood, Broward County, Florida.

Mandibular formula:

$$\frac{\text{L } 1234 \quad 0 \quad ab'b}{\text{R } 1234 \quad y \quad abd}$$

Left

A. 1. $b > a > b'$.
   2. All the molars are pointed. b' is in line with a and b.

B. 1. None of the incisors is smoothly tapered.
   2. $3 > 4 > 1 > 2$.
   4. Base of $1 = 3 > 2 > 4$.

Right

A. 1. $d > b > a$.
   2. All the incisors are uniformly tapered except 1, which is angulate on its anterior margin.
   2. $4 > 3 > 2 > 1$ or $2 = 1$.
   3. The incisors are not as prominent as on the left.
   4. The base of 1 is broader than that of either 2, 3, or 4.

Sympetrum corruptum (Hagen) Figures 89, 90, 91, 92

Material studied.—One nymph from Southport, Jefferson Parish, La.

Mandibular formula:

$$\frac{\text{L } 1234 \quad y \quad ab}{\text{R } 1234 \quad y \quad abd}$$

Left

A. 1. $b > a$.
   2. The molars are fairly heavy, with broad bases.

B. 1. The incisors are tapered, but not sharply pointed.
   The tip of 2 is more rounded than that of the other three.
   2. $3 > 4 > 2 > 1$.
   3. The cleft between 3 and 4 is deeper than on the right.
   4. Incisor 3 has the broadest base.

Right

A. 1. $d = b > a$.
   2. The molars are short and stout, with broad bases.
   a is blunt; b and d are pointed.

B. 1. The incisors are short, pointed, and have rounded margins.
   2. $4 > 3 > 2 > 1$.
   3. The separation betwen 3 and 4 is not as pronounced as on the left.

Erythemis simplicicollis (Say) Figures 93, 94, 95, 96

Material studied.—Two nymphs from Shreveport, Caddo Parish, La.; one nymph from Norco, St. Charles Parish, La.

Mandibular formula:

L	1 2 3 4	y	a b′ b
R	1 2 3+4	x y	a b d or a b d d′

Left

A. 1. $b > a$.
   2. b is heavy and blunt, with a broad base.

B. 1. The incisors are rounded.
   2. $3 > 4 > 2 > 1$.
   3. The clefts between the incisors are deeper than on the right.
   4. The bases of the incisors are approximately equal.

Right

A. 1. $d > b > a$.
   2. None of the molars is pointed.

B. 1. The posterior margin of incisor 1 is slightly angulate; the other incisors are rounded and fairly blunt.
   2. $3 > 2 > 1 > 4$.
   3. The incisors are not as strong as on the left.
   4. The base of 3 is wider than the base of any other incisor.

Calvert (1927) gives the following formula for *Erythemis:*

L	1 2 3 4	y	a b or a b′ b
R	1 2 3 4	x y	a b d

Celithemis sp. Figures 97, 98, 99, 100

Material studied.—Two nymphs from Chatham, Jackson Parish, La.

Mandibular formula:

L	1 2 3 4	y	a b
R	1 2 3+4	y	a b d d′–

Left

A. 1. $b > a$.
   2. The molars terminate in sharp points.

B. 1. The incisors are uniformly tapered. 1 and 2 have pointed apices; 3+4 are more rounded.
   2. $3 > 4 > 2 > 1$.

3. 3 and 4 are almost completely fused.
4. Base of 3+4 = 2 > 1.

C. 1. *y* is a well-developed, pointed tooth.

Right

A. 1. *b* > *d* > *a*.
2. *a* and *b* are sharply pointed; *d* is rounded. *d'* may or may not be present on the anterior margin of *d*. If present, it is smaller than any of the other molars and is pointed.

B. 1. The incisors are smoothly tapered to sharp points. The clefts between the incisors form sharper angles than on the left. In the left, the clefts are rounded.
2. 4 > 3 = 1 > 2.
3. 3 and 4 are less completely fused than in the left.
4. 1 has a wider base than 2 and is only slightly narrower than the fused bases of 3+4.

Plathemis lydia (Drury) Figures 101, 102, 103, 104

Material studied.—Three nymphs from Legion, Kerr County, Texas, and one nymph from Angie, Washington Parish, La.

Mandibular formula:

L	1 2 3+4	y–	a b	
R	1 2 3+4	y	a b d	

Left

A. 1. *b* > *a*.
2. *a* and *b* are both pointed. The point of *a* is sharper than *b*.

B. 1. All the incisors are uniformly tapered except the anterior margin of 3 which is rounded at the base. 1 and 2 are pointed; 3+4 are rounded.
2. 3 > or = 4 > 1 > 2.
3. 3 and 4 are almost completely fused. Only a slight cleft separates them at their tips.
4. The base of 3+4 > 2 = 1. The base of 3+4 occupies approximately half of the incisor margin.

C. 1. *y*– is but a slight, rounded protrusion on the posterior margin of the mandible.

Right

A. 1. *b* > *d* > *a*.

2. The molars are not sharply pointed, but are slightly rounded at their tips. The base of b narrows and extends proximally.

B. 1. All the incisors are uniformly tapered. 3 is pointed; 2 and 1 are rounded.
2. $3 > 1 > 2$.
3. The incisors are not as strong as on the left. 3 and 4 have apparently fused completely to form a single tooth.
4. The base of $3 = 1 > 2$.

C. 1. y is small and rounded.

Pachydiplax longipennis (Burmeister) Figures 105, 106, 107, 108

Material studied.—Three nymphs from Hollywood, Broward County, Florida.

Mandibular formula:

$$\frac{L\ 1\,2\,3\quad y\quad a\,b'\,b\,b^2}{R\ 1\,2\,3\quad y\quad a\,b\,d}$$

Left

A. 1. $b > a > b' = b^2$.
2. b is rounded; a is rounded. b' is located anteriorly to b at its base; b^2 is located posteriorly to b. Both b' and b^2 are in a direct line with a and b.

B. 1. Incisors 1 and 3 are uniformly tapered and are pointed. 2 is slightly angulate.
2. $3 > 2 > 1$ or $2 = 1$.
3. Teeth 3 and 4 are fused completely, thus forming a single tooth.
4. 3 is broader than either 1 or 2.

Right

A. 1. $a > b = d$.
2. The molars are pointed, but not sharply.

B. 1. The incisors are uniformly tapered and terminate in sharp points.
2. $4 > 3 > 2 > 1$.
3. 3 and 4 are entirely fused.
4. The base of $1 > 2 > 3+4$.

Pantala hymenea (Say) Figures 109, 110, 111, 112

Material studied.—Two nymphs from Bayou Chicot, Evangeline Parish, La.

Mandibular formula:

$$\frac{\text{L } 123{+}4 \quad 0 \quad ab}{\text{R } 1234 \quad y \quad abcd}$$

Left

A. 1. $b > a$.
   2. Both molars are stout and pointed.

B. 1. The incisors are not angulate, but the anterior margin of 3 is not smoothly tapered. The tips are rounded.
   2. $3 > 4 > 2 = 1$.
   3. The incisors are more prominent than on the right.
   4. The base of $1{+}2 = 3{+}4$.

Right

A. 1. $a = b = d > c$.
   2. All the molars are pointed conical structures. They arise abruptly from the mandibular surface, i.e., they do not have broad bases.

B. 1. The incisors are smoothly tapered; the tips are round.
   2. $4 > 3 > 1 > 2$.
   3. The incisors are not as strong on the left.
   4. Base of $3{+}4 > 1 > 2$. The base of $3{+}4$ occupies approximately one-half of the apical margin.

Calvert (1927) gives the mandibular formula for *Pantala* as $\frac{\text{L } 1234 \quad 0 \quad ab}{\text{R } 1234 \quad xy \quad abd}$. Tooth x was not present in either specimen examined in this study. The differences in these formulae may be the result of the differences in lettering the molars, as was discussed previously.

Tramea onusta Hagen Figures 113, 114, 115, 116

Material studied.—Two nymphs from Doss, Gillespie County, Texas.

Mandibular formula:

$$\frac{\text{L } 122'34 \quad y \quad abcc'}{\text{R } 1234 \quad y \quad abcd}$$

Left

A. 1. $b > a > c = c'$.
   2. All the molars are pointed and have broad bases. c and c' have a common base.

B. 1. All the incisors except 3 taper smoothly to points.
   2. $3 > 4 > 2 > 1$.
   3. The incisors are more prominent than on the right.

Right

A. 1. $d > b > a > c$.
   2. All are fairly stout, do not terminate in sharp points. Their sides are rounded. The two most distal molars do not have a common base as in the left.

B. 1. All the incisors are smoothly tapered.
   2. $4 > 3 > 2 > 1$.
   3. The incisors are not as heavy as on the left.

Calvert (1927) gives the mandibular formula for *Tramea* sp. as

$$\frac{\text{L } 1234 \quad y \quad abcd}{\text{R } 1234 \quad y \quad abcd}.$$

The genera in Libellulidae are the most difficult to arrange in a phylogenetic sequence. The genera studied may be grouped thus:

I. *Orthemis, Ladona, Cannacria, Perithemis*
II. *Sympetrum, Erythemis, Celithemis, Plathemis, Pachydiplax*
III. *Pantala, Tramea*

These groups may be differentiated as follows: I. y absent on left, y present on right, three molars on right; II. y present both right and left, three molars on right; III. y may or may not be present on left, four molars on right.

I. *Orthemis* is considered the most primitive of this group, because $2'$ is present on the anterior margin of 2 on the left, a condition similar to the subfamily Corduliinae. $2'$ is lacking in all subsequent members of this group. There are only two molars on the left in *Orthemis*.

If arranged according to the molars of the left, the rest of the series is *Ladona, Cannacria, Perithemis*. *Ladona* has but two molars, a and b, as does *Orthemis*. In *Cannacria* there is a small third molar between a and b. This tooth is called b' rather than

c or *d*, because it is in direct line with *a* and *b* and is closer to *b* than to *a*. In *Perithemis* the three molars are almost equal in size. However, the third molar is not in the position of *b′*, but is considered to be molar *d*.

II. In regard to degree of fusion of the third and fourth incisors the following series is obtained: *Sympetrum, Erythemis, Celithemis, Plathemis, Pachydiplax*. There is little fusion in *Sympetrum;* in *Celithemis* 3 and 4 are more fused on the left than on the right. 3 and 4 constitute a single tooth on the right mandible of *Plathemis,* but there is a slight cleft between 3 and 4 on the left. In *Pachydiplax* there are but three incisors both right and left, indicating that 3 and 4 have completely fused.

There are only two molars on the left in *Sympetrum, Erythemis* and *Celithemis*. In *Plathemis* a small tooth, *b′*, is present on the anterior base of *b*, but it is not a separate tooth. *Pachydiplax* has two small teeth close to *b*, one anterior and one posterior.

III. *Pantala* and *Tramea* differ from all the other genera in the presence of a separate fourth molar in position *c* on the right mandible. For this reason these two are considered to be the most advanced.

Utilization in Taxonomy

Key to the Families

1. With a molar crest 2
   Without a molar crest 4
2. Molar crest forms an angle with the incisors anteriorly (incisor 1 adjacent to molar *a*) ..... Cordulegasteridae
   Molar crest parallel to incisors (incisor 1 widely separated from molar *a*) 3
3. Never more than one *m* on the crest ..... Aeschnidae
   More than one *m* on crest ..... Gomphidae
4. 2′ present on anterior margin of 2 ..... Corduliidae (Corduliinae)
   2′ absent on the anterior margin of 2 5
5. Incisor 2 smaller than all other incisors .. Corduliidae (Epophthalmiinae)
   Incisor 2 not markedly smaller than other incisors ..... Libellulidae

Table 1 contrasts these families more completely.

TABLE 1[1]

Summary of Family Characteristics

	Gomphidae	Cordulegasteridae	Aeschnidae	Epophthalmiinae	Corduliinae	Libellulidae
Molar crest	present	present	present	absent	absent	absent
No. of *m* on Crest	L 4–5 R 2–6	L 3–4 R 4–5	L 0–1 R 0–1	....	....	....
No. of incisor teeth	4	4	4	4	4	3–4
Relative extent of incisors	....	L 4 = 3 > 2 > 1 R 4 > 3 > 2 > 1	L, R 3 > 4 = 2 > 1	L 3 = 4 > 1 > 2 R 4 > 3 = 1 > 2	L 3 longest R 4 longest	L 3 > 4 > 2 > 1 or 3 > 2 > 1 R 3 > 4 or 3 longest
y	R + L –	R + L –	R + L –	R + L –	R + L + or –	R – L +
Misc.	.....	L crest & incisors form angle	crest of 2 prominent teeth, a, b	2 smaller than any incisors	2′ + ant. margin of 2	.....

[1] R = right; L = left; + = present; – = absent.

The genera and species studied may be differentiated on the basis of the following key.

GOMPHIDAE

1a. All the teeth of right crest equal or almost equal ..*Hagenius brevistylus*
1b. *a* and *b* larger than all *m* teeth 2
2a. Both crests set in soft, fleshy area Right crest much reduced *Progomphus obscurus*
2b. Crests not set in soft, flesh area 3
3a. Right crest smaller than the left .....*Ophiogomphus* sp.
3b. Right crest equal to the left 4
4a. Teeth *m* pointed .....*Dromogomphus spinosus*
4b. Teeth *m* rounded .....*Gomphus* sp.

AESCHNIDAE

1a. Trough between molars and incisors deep. *a'* and *b'* present on right *Anax junius*
1b. Trough between molars and incisors shallow. *a'* and *b'* absent on right 2
2a. Edge of left crest between *a* and *b* crenulate .....*Boyeria vinosa*
2b. Edge of left crest between *a* and *b* with distinct teeth (*m*).....3
3a. *k* present both right and left 4
3b. *k* present on right only .....*Epiaeschna heros*
4a. *m'* present on right .....*Coryphaeschna ingens*
4b. *m'* absent on both right and left .....*Nasiaeschna pentacantha*

CORDULIIDAE – EPOPHTHALMIINAE

1a. Left incisor 1 deeply hollowed out on proximal surface *Didymops transversa*
1b. Left incisor 1 not hollowed out on proximal surface .....*Macromia* sp.

CORDULIIDAE – CORDULIINAE

1a. *y* absent on left .....*Neurocordulia* sp.
1b. *y* present left and right 2
2a. *a b' b* present on left .....*Somatochlora linearis*
2b. *a* and *b* present on left.....*Tetragoneuria cynosura*

LIBELLULIDAE

1a. Four molars present on right 2
1b. Less than four molars present on right 3
2a. *a* and *b* on left .....*Pantala hymenea*
2b. *a b c c'* present on left .....*Tramea onusta*
3a. *y* present on right only 4
3b. *y* present on both right and left 7
4a. 2' present on left, not on right .....*Orthemis ferruginea*
4b. 2' absent both right and left 5
5a. Two molars only on left .....*Ladona deplanata*
5b. More than two molars on the left 6

6a. Three molars forming a straight line parallel to the incisors *Cannacria gravida*
6b. Three molars not forming a straight line parallel to the incisors *Perithemis tenera*
7a. Three incisors present both right and left .....*Pachydiplax longipennis*
7b. Does not have three incisors both right and left 8
8a. Three incisors present on right; four incisors on left ...*Plathemis lydia*
8b. Four incisors present both right and left 9
9a. Incisors 3 and 4 fused both right and left .....*Celithemis* sp.
9b. No fusion of 3 and 4 both right and left 10
10a. *a b' b* present on left; *x* absent on right .....*Sympetrum corruptum*
10b. *a b* present on left; *x* present on right .....*Erythemis simplicicollis*

Utilization in Phylogeny

Based on mandibular characters alone the phylogenetic arrangement of families (Figure A) agrees with the arrangement of Tillyard (1917). The Gomphidae are considered the stem form because of the heavy, elevated, multi-toothed molar crest. Cordulegasteridae is considered the most primitive offshoot of the gomphine line, because of the presence of a well-elevated molar crest with approximately the same number of teeth as in Gomphidae. Elevated molar crests are present in Aeschnidae, but the crests always bear fewer teeth than either Gomphidae or Cordulegasteridae. In the Corduliidae and Libellulidae the molar crest is absent; two, three or four single molars are present. Two of these molars are in the position of the anterior and posterior teeth of the former crest.

The Libellulidae and Corduliidae continue the trend of reduction of number of molars that is seen in both Cordulegasteridae and the Gomphidae. The Libellulidae and Corduliidae are believed to arise from the Cordulegasteridae rather than the Gomphidae, because the incisors of the Libellulidae and Corduliidae are more like those of Cordulegasteridae than those of the Gomphidae.

The arrangement of the genera within the families is based on trends discussed at the close of the descriptions of each family.

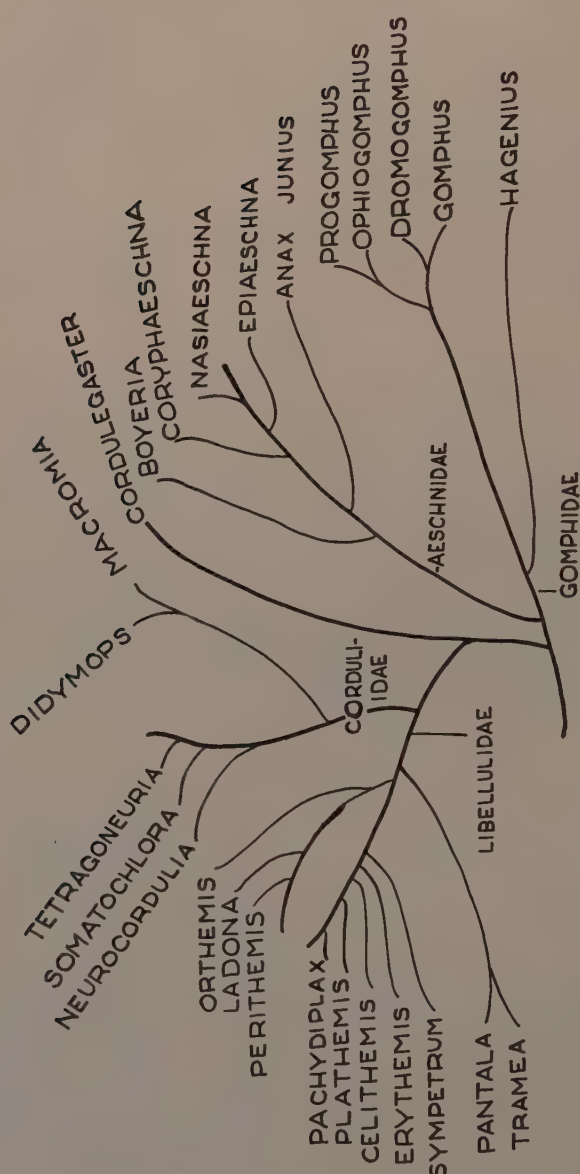
DIDYMOPS
MACRONIA
CORDULEGASTER
BOYERIA
CORYPHAESCHNA
NASIAESCHNA
EPIAESCHNA
ANAX JUNIUS
PROGOMPHUS
OPHIOGOMPHUS
DROMOGOMPHUS
GOMPHUS
HAGENIUS
AESCHNIDAE
GOMPHIDAE
CORDULI-
IDAE
LIBELLULIDAE
TETRAGONEURIA
SOMATOCHLORA
NEUROCORDULIA
ORTHEMIS
LADONA
PERITHEMIS
PACHYDIPLAX
PLATHEMIS
CELITHEMIS
ERYTHEMIS
SYMPETRUM
PANTALA
TRAMEA

FIGURE A

Summary

Only random notes and figures concerning the mandibles of Anisoptera nymphs are available in the literature. There have been no previous studies of the mandibles of genera representing the several families.

The mandibles of species of twenty-seven genera were studied to: (1) prepare a description of the mandibles of representative genera in each family, (2) determine whether or not the mandibles can be used for taxonomic purposes; and (3) ascertain if these structures are significant in determining phylogeny.

The mandible is a stout, roughly pyramidal structure with a triangular base. The inner or medial surface bears two sets of teeth, the distal incisors and the proximal molars. The molars may be in the form of a single crest or ridge or may be single teeth variously arranged. Mandibular armature is given in the form of a formula devised by Calvert (1927) which is used with some additions and modifications.

There are certain constant differences between the left and right mandibles, so individual descriptions and drawings are given for both mandibles of each genus. A preface to each family includes a general formula for the group and characters which are common to all members of the family. Each genus studied was distinct from all others based on mandibular characters. These characters can be observed without removing the mandible or damaging the specimen. Keys to the families and to the genera and species bring out the critical differences.

Based on mandibular features only, the genera are arranged phylogenetically. The most marked trend is the reduction in size and number of molars. In *Hagenius,* which is considered the most primitive, there is a straight, heavy molar crest armed with a maximum of six teeth, all about equal in size. In the most advanced member of the Gomphidae, *Progomphus,* there is a small, curved crest with only four teeth. In the Cordulegasteridae the molar crest is similar to that of the Gomphidae. In Aeschnidae the crest consists essentially of two large molars.

A molar crest is absent in Corduliidae and Libellulidae. In Epophthalmiinae there are but two molars in the position of the

molar crest, in Libellulidae there are as many as four relatively small, single molars.

In Libellulidae there is a gradual fusion of the third and fourth incisors to form a single tooth.

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Explanation of Figures

Generalized Mandibles

Figure 1.—Posterior surface, right mandible
Figure 2.—Posterior surface, left mandible
Figure 3.—Inner surface, right mandible
Figure 4.—Inner surface, left mandible
Figure 5.—Posterior surface, right mandible
Figure 6.—Posterior surface, left mandible
Figure 7.—Inner surface, right mandible
Figure 8.—Inner surface, left mandible

Specific Mandibles

Figures 9, 10, 11, 12,—*Hagenius brevistylus*
Figures 13, 14, 15, 16.—*Gomphus* sp.
Figures 17, 18, 19, 20.—*Dromogomphus spinosus*

Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface

Figures 21, 22, 23, 24.—*Ophiogomphus* sp.
Figures 25, 26, 27, 28.—*Progomphus obscurus*
Figures 29, 30, 31, 32.—*Cordulegaster* sp.

Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface

Figures 33, 34, 35, 36.—*Boyeria vinosa*
Figures 37, 38, 39, 40.—*Coryphaeschna ingens*
Figures 41, 42, 43, 44.—*Epiaeschna heros*

Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface

Figures 45, 46, 47, 48.—*Nasiaeschna pentacantha*
Figures 49, 50, 51, 52.—*Anax junius*

Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface

Figures 53, 54, 55, 56.—*Macromia* sp.
Figures 57, 58, 59, 60.—*Didymops transversa*

Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface

Figures 61, 62, 63, 64.—*Neurocordulia* sp.
Figures 65, 66, 67, 68.—*Somatochlora linearis*
Figures 69, 70, 71, 72.—*Tetragoneuria cynosura*

Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface

Figures 73, 74, 75, 76.—*Orthemis ferruginea*
Figures 77, 78, 79, 80.—*Ladona deplanata*
Figures 81, 82, 83, 84.—*Cannacria gravida*
Figures 85, 86, 87, 88.—*Perithemis tenera*

Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface

Figures 89, 90, 91, 92.—*Sympetrum corruptum*
Figures 93, 94, 95, 96.—*Erythemis simplicicollis*
Figures 97, 98, 99, 100.—*Celithemis* sp.
Figures 101, 102, 103, 104.—*Plathemis lydia*
Figures 105, 106, 107, 108.—*Pachydiplax longipennis*

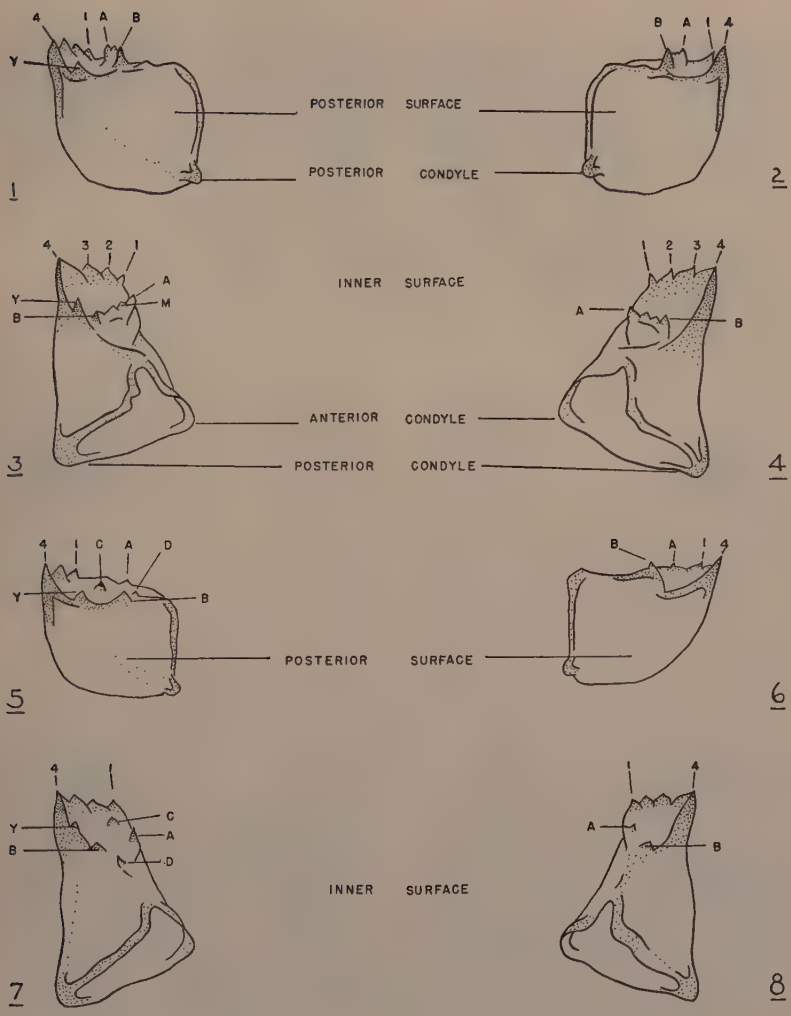
Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface

Figures 109, 110, 111, 112.—*Pantala hymenea*
Figures 113, 114, 115, 116.—*Tramea onusta*

Vertical rows

1.—Right mandible, posterior surface
2.—Right mandible, inner surface
3.—Left mandible, inner surface
4.—Left mandible, posterior surface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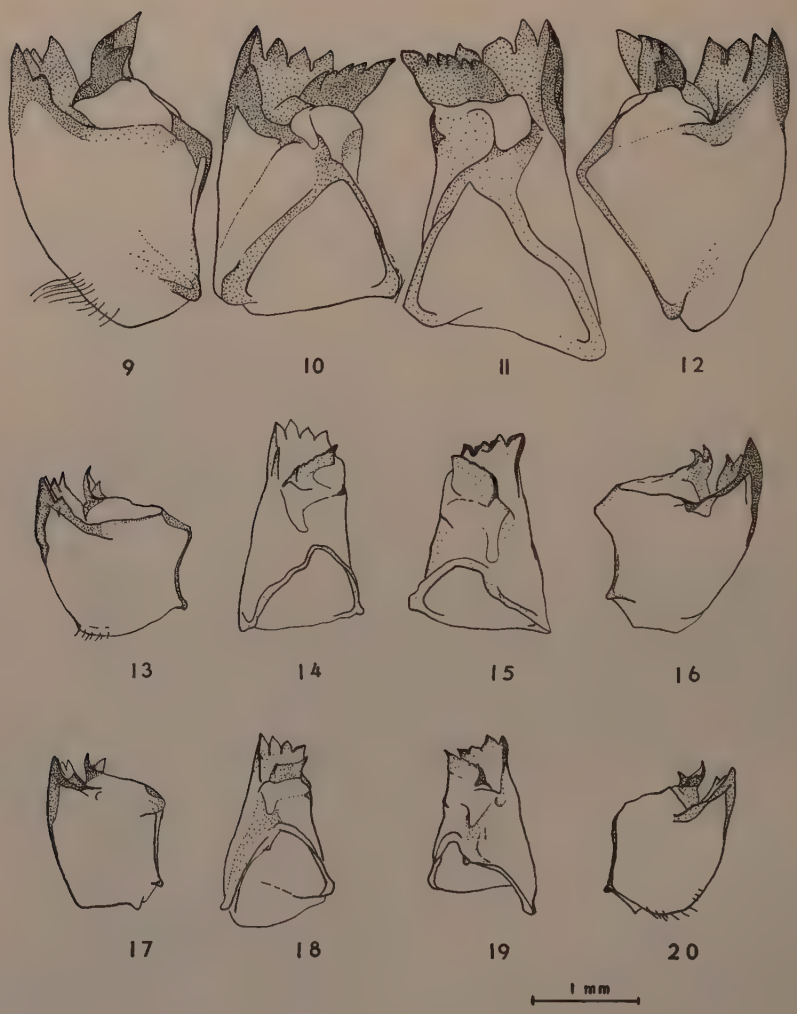
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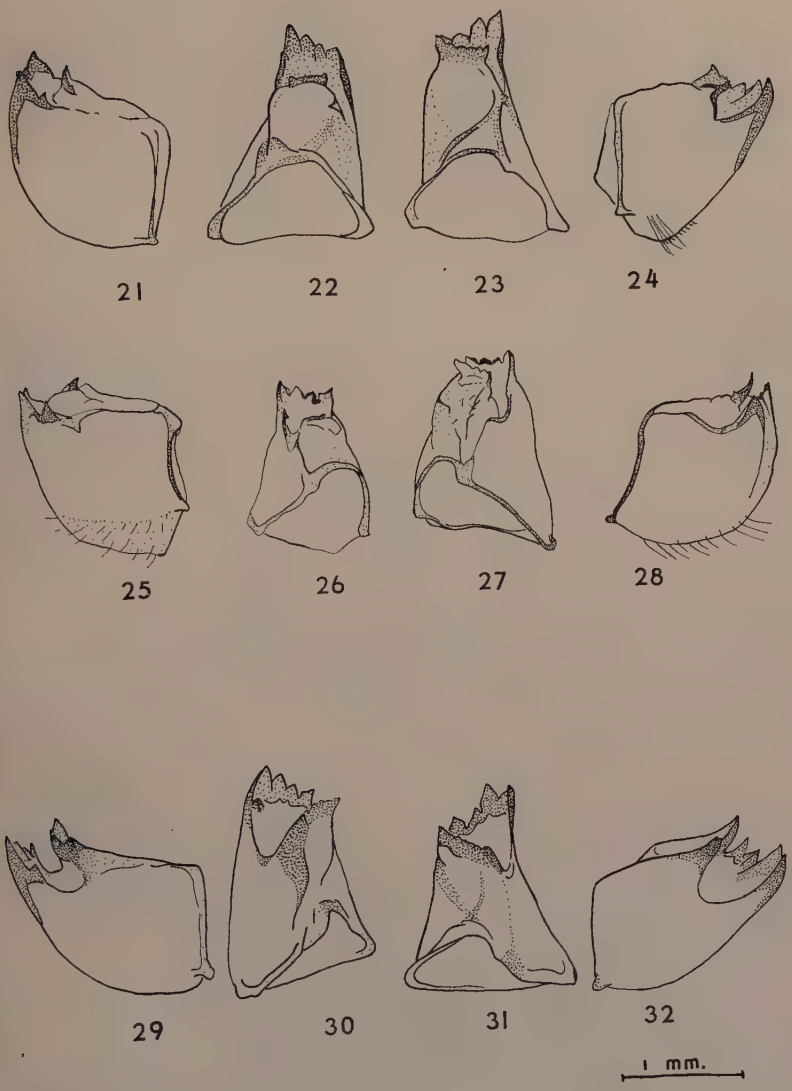
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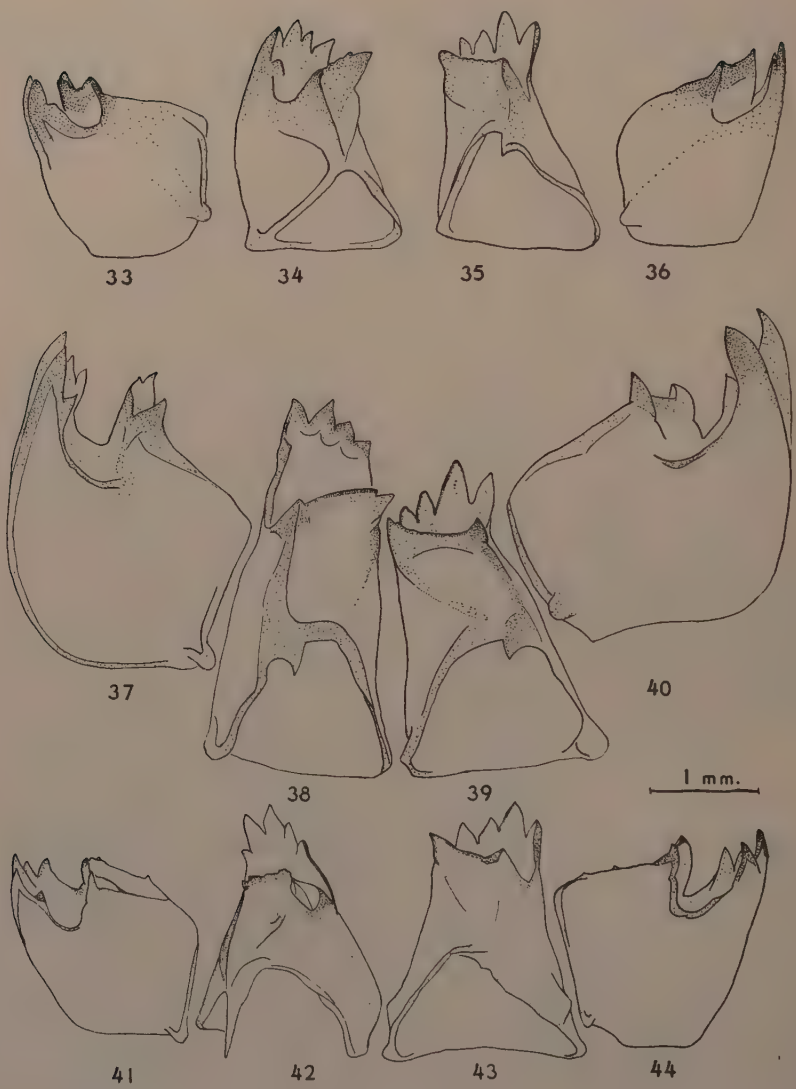
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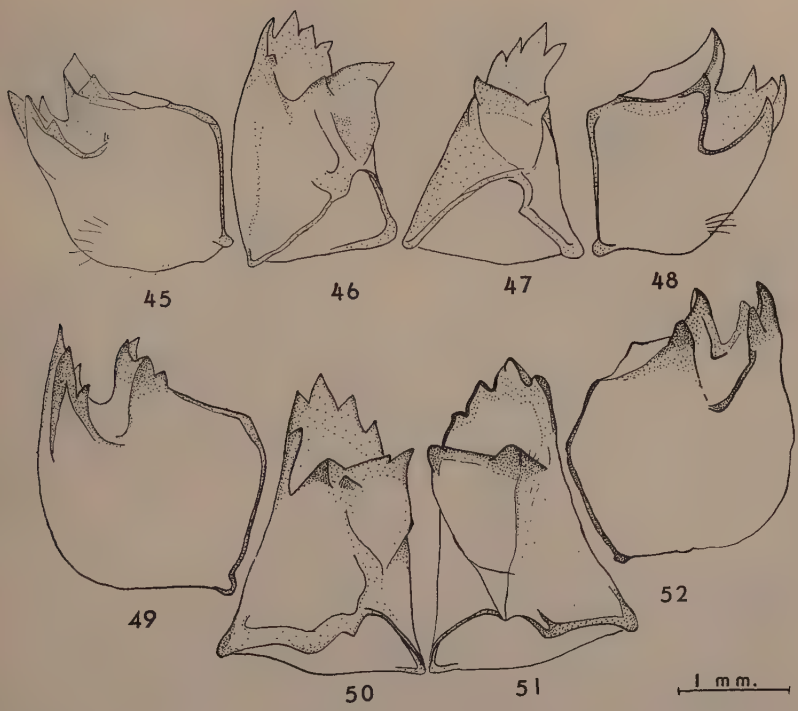
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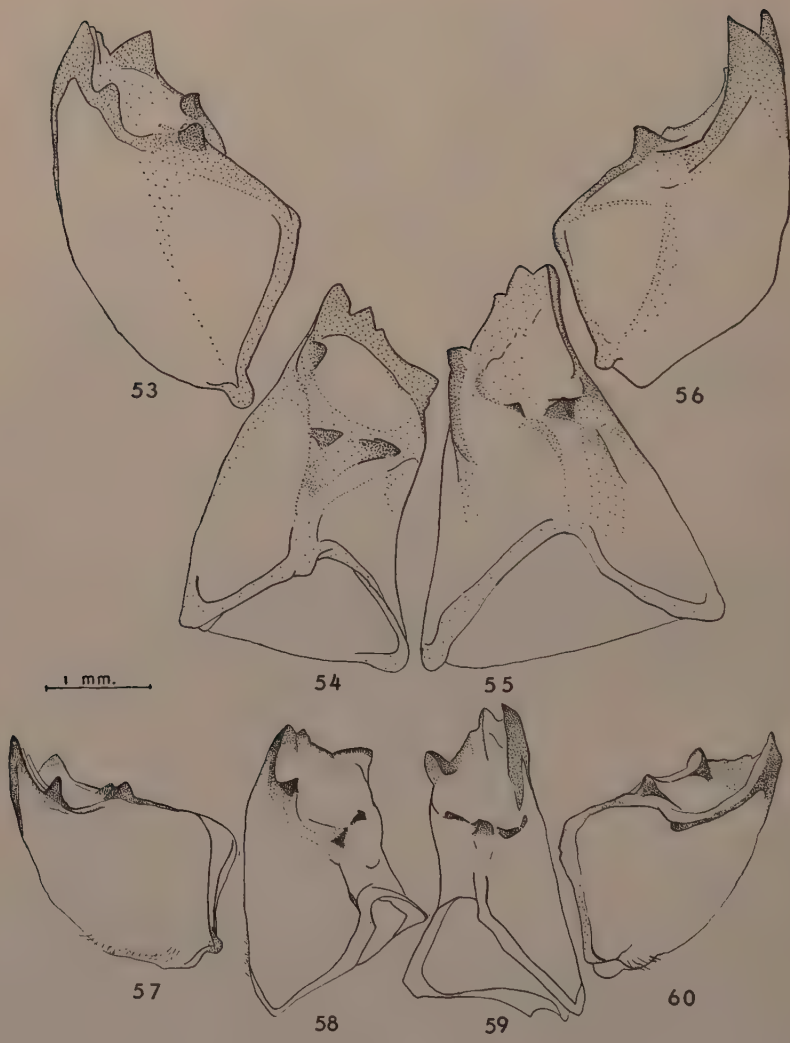
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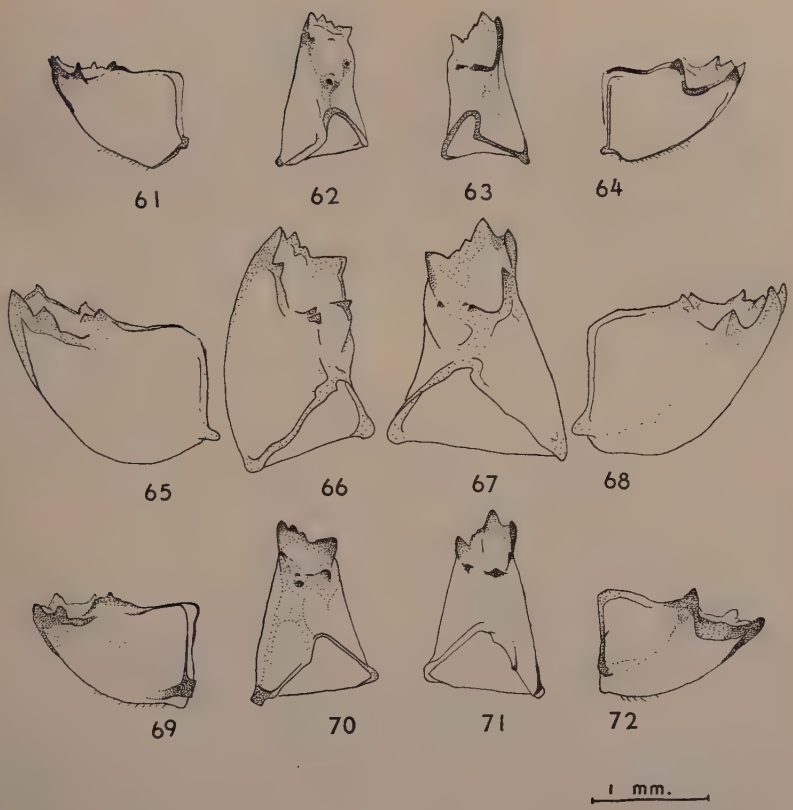
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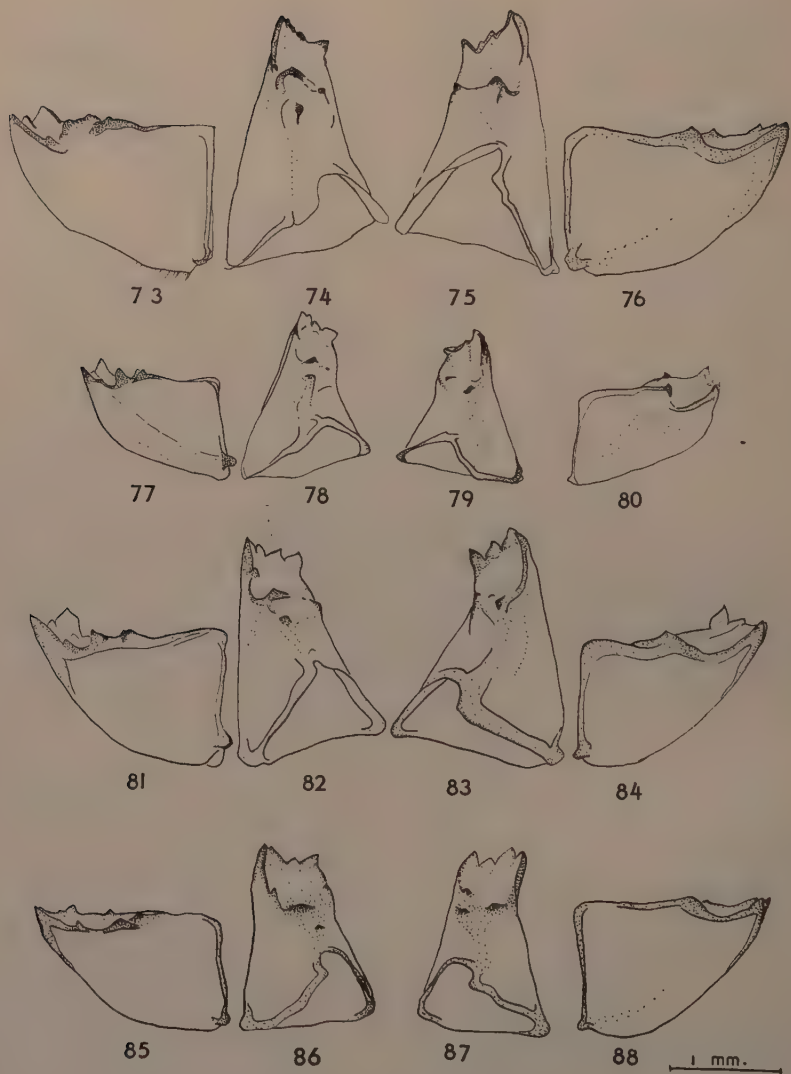
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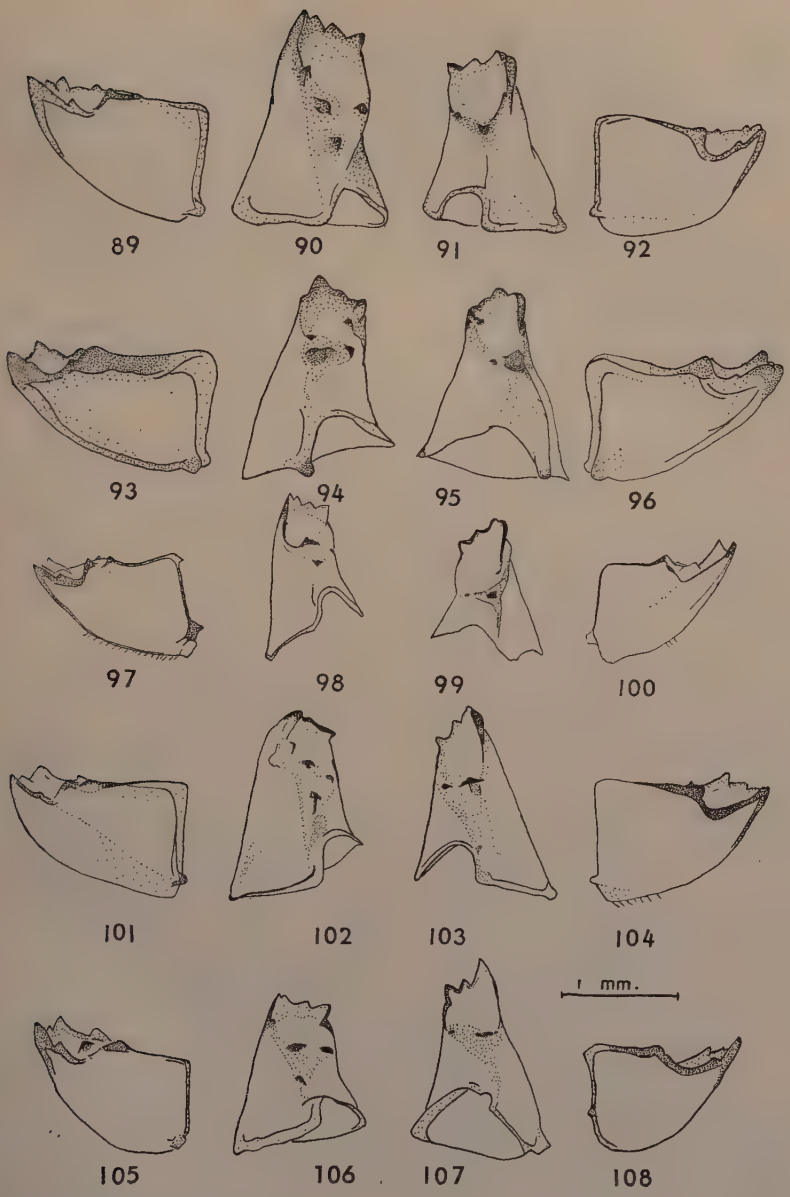
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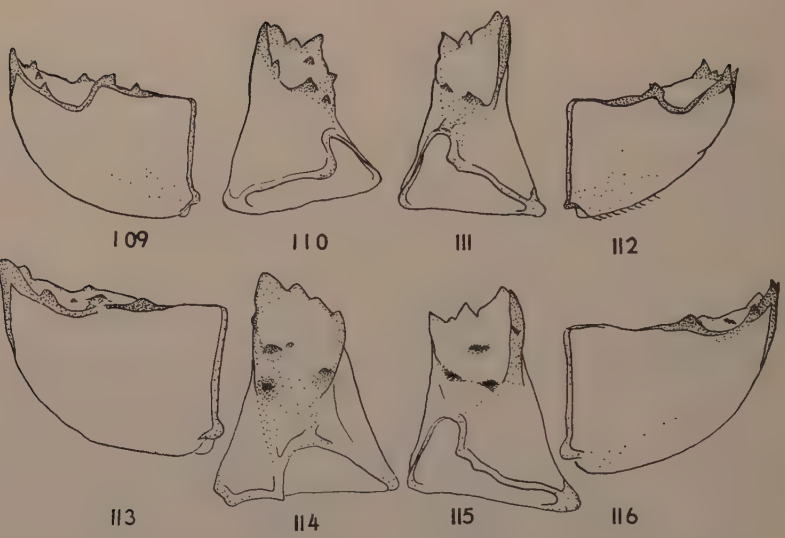
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110
111
112
113
114
115
116

INDEX TO THE GENERA AND SPECIES

New Genera and Species are Indicated by Bold Face Numerals

Aegomorphus, 74
Aeolacris, 106
Ammophila, 145
Anax, 168
approximatus, Figulus, **61**
assimile, Sceliphron, 148
atratus, Prionony x, 142
auripes, Isodontia, 144
azteca, Isodontia, 143

barythripoides, Eschatothrips, 89
bella, Aeolacris, 110
bilineatus, Orthothrips, **96**
boneti, Orthothrips, **97**
Boyeria, 166
brevistylus, Hagenius, 160

caementarium, Sceliphron, 147
californicum, Chalybion, 149
caligo, Microtylopteryx, **123**
campestris, Ammophila, 147
Cannacria, 177
carolina, Podium, 150
caternaulti, Aeolacris, 107
Celithemis, 179
centurio, Procolpia, **43**
Chalybion, 149
Chamaeothrips, 79
champlaini, Microdon, 10
chiapensis, Microtylopteryx, **114**
clavatoris, Mystrothrips, 93
claviger, Erkosothrips, 83
clypeata, Podalonia, 144
coarctatus, Microdon, 6
Cordulegaster, 164
corruptum, Sympetrum, 178
Coryphaeschna, 166
cothurnatus, Microdon, 13
crenulata, Legua, 31
cynosura, Tetragoneuria, 173

daggyi, Palmodes, 141
dammermani, Mystrothrips, 93
decoratus, Chamaeothrips, **80**
Dendezia, 71
deplanta, Ladona, 176
Didymops, 171
Dromogomphus, 162
dubius, Orthothrips, **98**

emarginata, Procolpia, 41
Epiaeschna, 167
Episcopotettix, 33
Erkosothrips, **81**
Erythemis, 179
Eschatothrips, **88**

ferruginea, Orthemis, 175
Figulus, 59
flavescens, Glyptothrips, 91
flavipenne, Podium, 151
floridensis, Erkosothrips, **84**
foveatus, Figulus, 64
fusiformis, Microtylopteryx, 124

Ganelius, 70
gazellae, Figulus, 64
globosus, Microdon, 5
Glyptothrips, 91
Gomphus, 161
götzeni, Syndesus, 73
granulosa, Prorhachis, 24
gravida, Cannacria, 177

Hagenius, 160
harrisi, Isodontia, 143
harti, Ammophila, 146
heros, Epiaeschna, 167
Hoplogonus, 72
hymenea, Pantala, 182

ichneumoneus, Sphex, 139
inclarata, Procolpia, 51
ingens, Coryphaeschna, 166

insignis, Proracris, 30
integricollis, Figulus, 65
interior, Erkosothrips, **84**
Isodontia, 143

jucundus, Chamaeothrips, 80
juncea, Ammophila, 147
junius, Anax, 168

kolbei, Nigidius, 67

Ladona, 176
lanceolatum, Microdon, 4
lankesteri, Procolpia, **46**
laticollis, Figulus, 65
Legua, 31
lilliputanus, Figulus, 66
linearis, Somatochlora, 173
Lissotes, 72
longipennis, Pachydiplax, 181
lupinus, Figulus, 67
lydia, Plathemis, 180

Macromia, 170
madagascariensis, Ganelius, 70
magnus, Figulus, **62**
manicatus, Figulus, 67
manitobensis, Microdon, 4
marginalis, Figulus, 61
marmoratus, Microdon, 5
megalogaster, Microdon, 12
Microdon, 4
Microtylopteryx, 114
minor, Procolpia, 54
Mixogaster, 15
Mohavacris, 126
Mystrothrips, 92

Nasiaeschna, 168
Neurocordulis, 172
Nigidius, 67
Novonigidius, 69
nuptialis, Xomacris, 26

oberndorferi, Nigidius, 68
obscurus, Progomphus, 163
octomaculata, Aeolacris, 106
onusta, Tramea, 182
Ophiogomphus, 162
Orthemis, 175
Orthothrips, 94

Pachydiplax, 181
Palmodes, 141
Pantala, 182
papuanus, Figulus, 67
pensylvanicus, Sphex, 140
pentacantha, Nasiaeschna, 168
Perithemis, 177
pictipennis, Microdon, 8
piperi, Microdon, 15
Plathemis, 180
Podalonia, 144
Podium, 150
Porcothrips, 98
Prionony x, 142
procera, Ammophila, 145
Procolpia, 41
Progomphus, 163
Proracris, 28
Prorhachis, 21

regalis, Procolpia, 42
renieri, Dendezia, 71
reticulatus, Erkosothrips, 85
reticulotubus, Eschatothrips, 90
robusta, Microdon, 11
ruficrus, Microdon, 9

Sceliphron, 147
scotti, Figulus, **61**
sculpturus, Erkosothrips, 86
seychellensis, Figulus, 60
silvarum, Erkosothrips, 87
simplicicollis, Erythemis, 179
Somatochlora, 173
Sphex, 139
spinosus, Dromogomphus, 162
spirifex, Sceliphron, 149
striatus, Figulus, 64
sulcirostris, Episcopotettix, 34
Sympetrum, 178
Syndesus, 73

tenera, Perithemis, 177
Tetragoneuria, 173
thomae, Prionony x, 142
timberlakei, Mohavacris, 126
Tramea, 182
transversa, Didymops, 171
tristis, Microdon, 14
tydei, Podalonia, 145

umbrosus, Sphex, 140
urnaria, Ammophila, 146

vagatus, Nigidius, 69
variegata, Mixogaster, 15
variegatus, Eschatothrips, 90
vinosa, Boyeria, 166
vinsoni, Figulus, **62**

wheeleri, Microdon, 7
whitcombi, Eschatothrips, **90**
worthi, Microtylopteryx, **117**

Xiphodontus, 70
Xomacris, **25**

yamaskanensis, Neurocordulis, 172